ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

FLOATING ARCHITECTURE DESIGN PROCESS MODELING SUPPORTED BY RULE-BASED DECISION-MAKING

Ph.D. THESIS

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Department of Architecture

Building Sciences Programme

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

YÜZEN MİMARİ TASARIMI SÜREÇ MODELLEMESİNDE KURAL TABANLI KARAR VERME

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Ayça Tartar, **a Ph.D.** student of ITU **Institute of Science 502052610** successfully defended the **thesis** entitled "**FLOATING ARCHITECTURE DESIGN PROCESS MODELING SUPPORTED BY RULE-BASED DECISION MAKING**", which she prepared after fulfilling the requirements stipulated in relevant legislations, before the jury whose signatures are below.

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To my family and friends,

FOREWORD

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June 2012 Ayca TARTAR

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ABBREVIATIONS

AI	**:** Artificial Intellegence
ANN	**:** Artificial Neural Network
CAD	**:** Computer Aided Design
DIPS	**:** Design Information Processing System
FADPM	**:** Floating Architectural Design Process Modeling
FIS	**:** Fuzzy Inference System
GT PPM	**:** Georgia Tech Process to Product Modeling Tool
ITU	**:** Istabul Technical University
MF	**:** Membership Function
RIBA	**:** Royal Institute of British Architects
TLP	**:** Tension Leg Platform
UNFPA	**:** United Nations Population Fund
VLF	**:** Very Large Floating

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FLOATING ARCHITECTURE DESIGN PROCESS MODELING SUPPORTED BY RULE-BASED DECISION MAKING

SUMMARY

Given the effects of worldwide phenemonal incidents, climate change, urbanization growth and social demands, the future after effects seem uncertain. Reducing uncertainty by predicting climate change and its impacts can be achieved; however, uncertainty can not totally be eliminated, so adaptive strategies become an important decision support for architectural design process problems. Floating architecture is the focus field of the study, accepted as an adaptive strategy for future phenomal world changes. Fuzzy logic is the tool to evaluate a new design process model for floating architecture. The thesis aims to use fuzzy logic to make decisions in a floating environment, which is composed of imprecision, uncertainity and inconsistent information, and to perform a wide variety of physical and mental tasks without resorting to any measurement or computation. The primarily goal is to provide a mental process to create a new model proposal for floating architecture design process.

In this study, selected floating architectural system is tension legged platform which has semi-submerged tension legs and is accepted as submersible and used for coastal aquaculture in relatively shallow and intermediate water depths. The floating platform structure is connected to seabed by tendon ropes. In the cases of small wave amplitude, during the stablization process of the floating strcuture, the wave-induced structural responses form a displacement and vibration in the structure, causing health hazards for the users of the floating structure. Instead of controlling the floating structural system with a controller, a pre-controlled design process model is discussed in this study. All dominant parameters of the proposed model are analyzed with expert view, and then required stabilization parameters are determined. This proposed technique improves the limitations of the whole strucuture's response behaviour under constant wind and wave motion, using the advantage of this resonance problem by transforming it to an adaptive strategy. However, ensuring the stability of floating structures is a complex problem. Correct estimation of all the possible external forces is vital for stability and durability. Among these external forces, wave forces are likely to be the most dominant forces challenging researches for centuries to study on wave and floating body interaction. Simplified models that have already been developed and response of these floating bodies to wave forces have recently been studied numerically, with physical models, with field measurements, computer algorithms, numerical and experimental studies. However, in this study, when analyzing the dynamics of floating bodies, a linguistic approach is presented which consequently aims to stimulate the human's process of thought and judgement. The proposed linguistic rule-based model turns out to be a support tool, helping naturally to surface the complex nonlinear chaotic resonant character of

floating structures. By using linguistic rule bases, stability and stabilization problems of tension leg platform type floating structures are discussed and within the framework of the pre-designed process method, in three distinct fields: first the dimensions of the structure, then the correlation of the dimensions with wave-wind motion effects and finally the required vibration levels for user comfort are obtained.

Fuzzy-rule based modeling is used in the study because of its unique advantages for solving complex identification and control problems for nonlinear systems. The passive dynamic absorbers are used to reduce system vibration of floating structures, however in nonlinear systems they can not work properly and may even result in chaotic vibration. Thus, in the study, to reduce this risk, great consideration is given to the pre-design dimensions of the floating structues.

The design process of floating architectural structures requires a high level of expertise and advanced naval architecture knowledge, so the linguistic rule-bases of the model are derived from the past experience of the experts, whose evaluations are based on their experience rather than on objective measurements. With the help of the predetermined rules, the model works without considering quantitative measurements focusing on qualitative linguistic variables that are used mostly in fuzzy environments.

Based on the idea of experimenting the potential of water as an alternative and active design site, the determined dynamic constraints of its design process are discussed and a generative rule-based model for decision support of floating architecture design process modeling is formed. Data of constraints are taken from the literature of naval architecture and consequently the building technology frame the model. Thus, the designated model operates as a support for regaining floating architecture identity of the future.

In the study, motion effects on the user comfort are accepted as an active design element. A correlated relationship model between sea state and user motion comfort target requirements under motion effects is formed taking motion-vibration as an initial integrative design modeling fragment.

The proposed model is to engage and evaluate a cause for action for the future of floating architectural design process. Motion effects causing vibration on human biodynamic are discussed under the environmental parameters with expert view approach frame the rule-based decision support model.

In this study, the intention is not using a model accessing a situation with limited conditions in given areas with predefined values. In fact, the proposed model tries to discuss the whole system behavior under the very changeable atmosphere of sea state. Formulating the research problem of the model; the study is an applied research focusing on motion effects on human comfort levels under constant wave and wind effects, using multidisciplinary expert view correlated with process design systems. The instrument for analyzing data is fuzzy logic and linguistic decision support systems is used for evaluating design modeling with changeable site-specific environmental data and recent research data of floating structures. The intention of the study is to discuss the information about floating structures and then with the cooperative assistance of fuzzy logic, to compose a ruled based design process model.

The floating architectural design process modeling can be classified as a complex system dependent mostly to the environmental changes. In this study by simplifing the level of complexity of system input - output parameters and the correlation between each parameter causing complexity a new design model is proposed. For the overall situation an expert is invited to form the final rule-bases eliminating amongst a set of previously experienced rules. In this manner, uncertainty of the data in process modeling design of floating architecture is transformed to the rule bases of the fuzzy system.

The nodes in a neural network are neurons, whereas the nodes in a fuzzy network are rule bases. The objective of the proposed design process model is to predict the future consequences of determined floating design preferences and to change and evaluate them according to the rule-bases to improve the quality of design. Rules formed in the study with three input parameters and an output are evaluated with expert opinion. With the support of expert opinion, these general rule bases are reduced to basic rule bases. Using the model in the pre-design phase, extreme flexibility due to learning ability and capability of nonlinear nature of fuzzy rules make the proposed model to be an appropirate tool for solving the motion characteristics correlated with user comfort needs.

In this study to overcome complexity and non-linearity associated with wave-wind interaction, a process flow is used. The process flow starts with literature research, after research phase, approaches to the problem are determined, then the limit conditions are discussed within the determined approaches and finally, the linguistic rule-based decision support tools are used with expert view in the application phase that involves floating sailing club in North-east Marmara region of Istanbul, Turkey.

YÜZEN MİMARİ TASARIMI MODELLEMESİNDE KURAL TABANLI KARAR VERME

ÖZET

Dünya gelecek senaryolarını etkileyen iklim değişikliği ve şehirleşme hızındaki artış gibi öngörülemeyen gelişmelerin, gelecek mimari tasarımlara etkileri belirsizliğini korumaktadır. İklim değişikliği ve yol açacakları hakkındaki tahminlerin belirsizliği azaltabilme başarısına karşın, dünya çapında engellenemeyen baskın belirsizliğin oluşturduğu ortamda, adapte olabilen stratejiler geliştirilmesinin, mimari tasarım problemlerinin çözümüne yararlı olabileceği düşünülmektedir. Çalışmada tartışılan yüzen mimari tasarım olgusu, dünyanın geleceğini etkileyen ekstrem oluşumlar için adapte olabilen esnek bir strateji olarak önerilmektedir.

Tezde, çok kriterli yaklaşılması gereken yüzen mimari yapı süreç tasarımı, kıyı yapıları, deniz teknolojileri, mimari yapı teknolojileri ve insan biyo-dinamiği gibi disiplinlerarası alanları da içeren bir çalışma içinde tartışılmıştır. Çalışmadaki litertür ve araştırma bölümünde, yüzen mimari yapı ile yeni stratejiler oluştururken, gemi inşaat mühendisliği, mimarlık ve yapı teknolojisinde kullanılmakta olan tasarım süreci yaklaşımları araştırılmış, ekstrem koşulları ve belirsizliği düzenleyebilen daha üreten bir yaklaşıma olan acil ihtiyaç çalışmanın sonraki süreç aşamalarının belirlenmesinde en önemli etkenler olarak kabul edilmiştir.Yüzer mimari tasarım değerlendirilirken, hareket, titreşim ve yüzerlik etkilerinin aktif tasarım öğesi desteği olarak kullanılması durumunda, bu alanların yeni ürün tasarım sürecine olumlu katkısı olacak şekilde kullanılabileceği görülmüştür. Böylece çalışmada su üstü mimarisinin geliştirilmesi gereken kriteri olan titreşim problemi, tasarım süreci önerisi oluşturulurken pozitif bir katalizör olarak kullanılmıştır.

Rüzgar ve dalganın yüzen yapıya etkidiği noktadan bağlandığı zemine kadar olan aktarımının meydana getirdiği yanal yükler, yüzen yapıda çeşitli hareketlere neden olmaktadır. Çalışmada rüzgar ve dalga etkileri, yüzen yapının yapısal stabilitesi açısından uzman görüşünden yararlanılarak değerlendirilmiş, etki dereceleri kural tabanına dönüştürülmüştür. Geliştirilen yöntem, yüzen mimari yapı boyutlandırması aşamasında yeni bir karar verme destek modeli olarak kullanılmıştır. Dilbilimsel kural tabanlı karar destek sistemi olarak bulanık mantıktan yararlanılmıştır. Yüzen yapı hareketini etkiyen dalga yüksekliği ile yapının borda yüksekliği, dalga uzunluğu ile yapının gelen dalga yönüne paralel olan kenar uzunluğu ve rüzgar hızı ile etkilediği üst yapı formu arasındaki ilişkiler uzman görüşü ile kural tabanı haline getirilmiştir. Dalga-rüzgar etkisi altında yapıda oluşan hareket seviyeleri, yüzen mimari tasarım süreci modellemesinde belirlenen dilbilimsel derecelendirme ile kural tabanı haline getirilmiş, 'Matlab' programı içinde kullanılmıştır. Yüzen mimari tasarımda yeni ürün modellemesi sürecinde uzman karar destek sistemi kullanılmış, geliştirilen dilbilimsel kural tabanı 'Matlab' içinde uygulanmıştır.

Çalışmanın amacı yüzen mimari süreç tasarımı için yeni bir metot geliştirmektir. Bunun için yeni bir yaklaşımla çalışmanın kendisinde de belirli bir süreç şeması oluşturulmuştur. Süreç şeması birbirini izleyen ve tetikleyen oluşumlar şeklindedir. Sürecin ilk aşaması olan ve tezin ikinci bölümünde yer alan araştırmalardan çıkan sonuçlara göre, ortaya çıkan problem için, uzman görüşüne başvurularak, disiplinler arası bir çalışma ile probleme yaklaşım tarzları, tezin üçüncü bölümünde belirlenmiştir. Tezin dördüncü bölümünde ise, çalışmadaki problemin içerdiği sınır koşullar ve problemin bu koşullar içinde ele alınış kapsamı belirlenmiştir. Bu kapsam ve koşullar içindeki probleme seçilen yaklaşım tarzına en uygun problem çözme araçları ise tezin beşinci bölümünde belirlendikten sonra, tezin altıncı bölümünde bir örnek çalışma alanında geliştirilen metod uygulanmıştır.

Çalışama sürecinin ilk aşaması olan araştırma aşamasında, tezin ikinci bölümünde, alternatif tasarım alanı olarak düşünülen su ortamının, zemin olarak, mimari tasarımda durumlar belirlenmiş normları aştığı ve uç noktalara ulaştığı zaman, durumların gerektirdiği yeni fonksiyonların tasarımlarının gerçekleştirilmesine imkan verebilmesi ve yüzen yerleşim oluşturma potansiyelinin değerlendirilmesine zemin hazırlayabilmesi gibi nedenlerle tercih edildiği görülmüştür. Karşıt açıdan bakıldığında, su üstü mimarisini bekleyen tehditlerin, iklim değişikliği ve su seviyelerindeki değişiklik sonucu yeni tasarım kaçınılmazlığının getirdiği acil yaklaşımların, eksik ve kusurlu mimari yapılaşmaya neden olabileceği ve bunun çözülmesi gereken bir problem olarak kabul edilmesi gerekliliğidir. Seller, su baskınları ve su seviyelerindeki değişimler gibi olumsuz çevresel afet ve oluşumlarının yarattığı insan yaşamını tehdit eden durumlarda, olağanüstü değişimlere karşı uyumlu strateji oluşturmamıza, su üstü mimari tasarımının destek olabileceğinin düşünülmesi çalışmada yüzen mimarinin kullanma amaçlarından biri olarak kabul edilmiştir. Tezin ikinci bölümü olan araştırma aşamasında, yüzen mimari tasarımın içerdiği fırsatlar ve karşılaşılabilinecek tehditler incelenmiştir. Yüzen mimarinin içerdiği fırsatlar, hareketli ve esnek yapısıyla olağanüstü değişimlere adapte olabilen strateji geliştirme imkanı vermesi, tehditler ise küresel ısınma ve iklim değişikliği ile sel ve su baskınları problemlerine açık olması, üstünlükleri, yeni fonksiyonlara cevap verebildiği için tercih edilen tasarım metodu olması ve manzarası ve doğaya yakınlığı ile tercih edilen yaşam alanı olması, zayıflıkları ise, yeni ürün tasarımı geliştirilmesi ihtiyacı ve kullanıcı konforu açısından yapının maruz kaldığı hareket etkisinin iyileştirilmesi gerekliliği kabul edilmiş ve bu kabuller yüzen mimari tasarımı için geliştirilen model yaklaşımları tezin üçüncü bölümü olan yaklaşımların belirlenmesi aşamasında kullanılmıştır.

Çalışmanın ikinci bölümü olan, araştırma alanına ait süreç şeması oluşturulurken, ilk olarak yüzen mimaride tasarım süreci modeli oluşturma metotları incelenmiştir. Yüzen mimari tasarım sürecinde karşılaşılabilecek problemler araştırılmıştır. Problemlerin çözüm yaklaşımları ise deniz teknolojisi, gemi inşaat mühendisliği, mimari tasarım ve yapı teknolojisi gibi disiplinler arası çalışmalardan elde edilen bilgilerle belirlenmiştir. Araştırmada kullanılan süreç şemasında alınan kararlarla, tasarım problemine bir çözüm metodu önerilmekle beraber aynı zamanda metodun uygulaması ile öncül ana karar alma örneği oluşturulmuştur.

Çalışmadaki beş süreç aşamasından ilk aşama olan araştırma aşamasında, tezin ikinci bölümünde, üç tasarım faktörünün birbirleriye olan ilişkisi içinde dış çevresel etmenler, 'iç–bilişimsel' etmenler ve bunların disiplinlerarası bilgilerle desteklendiği disiplinlerarası etmenleri içeren tasarım faktörleri, bütüncül bir yaklaşımla tartışılmıştır.

Araştırma sürecinden sonra, tezin üçüncü bölümü olan yaklaşımlar aşamasında, yüzen mimari süreç tasarımı problemini tartışabilmek için en uygun yaklaşımların; çevresel tasarım, performans tabanlı tasarım, yeni ürün geliştirme ve ürün-süreç tasarımı yaklaşımlarının olduğu görülmüştür. Bu yaklaşımlar, daha sonra yüzen yapı süreç tasarımı oluşturulurken kapsam içinde seçilen sistemin gerektirdiği koşulların sınırları içinde kullanılması gerektiğinden, tezin dördüncü bölümü olan sınır koşullar belirlenmesi koşullar ortaya konmuştur. Çalışmanın araştırma bölümünde, tezin dördüncü bölümü olan sınır koşulların ne olması gerektiğine, literatür ve diğer çalışmalar üzerinden yapılan araştırmalar sonucu karar verilmiştir. Belirlenen yaklaşımlar çalışmanın yaklaşımlar bölümünde ayrıca problemle olan ilişkileri açısından değerlendirilmiş ve bu yaklaşımlarla problemin ele alınması gerektiği kabul edilerek çalışma yönlendirilmiştir.

Yüzen mimari tasarım süreci için kullanılacak tezin beşinci bölümün olan araçların belirlenmesinde ise, yüzen mimari yapının içinde bulunduğu çevresel koşulların belirsizliği ve tahmin edilemezliğinin büyük rol oynadığı görülmüştür. Belirsizlik, bulanık mantık gibi dilbilimsel kural tabanlı destek sisteminin yüzer mimari tasarım sürecinin karar destek sistemi olarak kullanılmasına neden olmuştur. Çalışmada seçilen araç yani bulanık mantık, uygulama olarak Matlab programı ile çevresel ölçütlerin ve titreşim performans değerlerinin karşılıklı olarak uzman görüşüyle değerlendirilmesinden sonra araştırmadaki problemin dilbilimsel karar destek sistemi olarak kural tabanı haline getirilmesi aşamasında kullanılmıştır. Çalışmada yüzen mimari yapı boyutlandırmasında rüzgar-dalga ilişkisi içinde istenen titreşim performansını elde edebilmek için uzman görüşüyle belirlenmiş kural tabanı, ileride yapılacak yüzen mimari yapılar için bir karar destek sistemi olarak kullanılmak üzere önerilmiştir.

Yüzen mimari tasarımı etkileyen en önemli parametrelerin dalga ve rüzgar ve akıntı gibi yapıya bağlı olmayan çevresel kriterler olduğu kabul edildiğinde yüzen mimari süreç tasarımına yaklaşımın, çalışmada çevresel tasarım yaklaşımı olması ve kriterlerin çevresel tasarım odaklı öğelerden oluşturulmasına karar verilmiştir. Çalışmada kullanılan dış yani yapıya bağlı olmayan çevresel etmenlerin listesi bulunmaktadır. Bu kararı alırken gemi inşaat mühendisliği ve mimarlık alanı yapı teknolojileri bölümlerinden uzmanlara görüşülerek karar verilmiştir.

Çevresel tasarım yaklaşımı olarak yüzen yapı süreç tasarımı içinde dalga ve rüzgârın mimari boyutlandırmaya olan etkilerin incelenmesinin nedeni aynı zamanda performans tabanlı bir yaklaşımla yüzen yapı tasarımında kullanıcı konforunu etkileyen titreşime rüzgar ve dalganın neden olmasıdır. Titreşimin, insan sağlığını tehdit edici boyutlara ulaşan ve çeşitli hastalıklara neden olan etkileri, çalışmada önerilen yüzer mimari yapı tasarım süreci içinde de iyileştirilmiştir.

Kullanıcı konforu açısından değerlendirildiğinde titreşimin, yüzen mimari yapı konfor değerlerini sağlamasından da öte insan sağlığını tehdit eden ve mimari yapının tercih edilmemesine neden olabilecek en önemli yapı performans değeri olarak kabul edilmesi gerektiği görülmüştür. Bu açıdan bakılarak performans tabanlı tasarım öğesi olarak titreşimin dezavantajlı etkilerinin giderilmesinin yeni ürün geliştirmedeki ilk aşama olan ihtiyaç olgusu olarak kullanılması gerektiği düşünülmüştür. Bu ihtiyacın ise ürün süreç modelleme yaklaşımı içinde bir gereklilik olarak ele alınıp tasarımı geliştiren bir pozitif katalizör olarak kullanılması amaçlanmıştır. Çevresel koşul olan dalga-rüzgâr etkisinin, yapı titreşim performansına etkisinin meydana getirdiği sağlık probleminin çözümü için yeni ürün tasarımı kullanılmıştır. Titreşimin oluştuğu yer ve nedenleri incelenerek yeni ürün geliştirme yaklaşımındaki ihtiyacın titreşimin mümkün olan en aza indirildiği yüzen yapıyı tasarlamak olduğu görülmüştür. Bunun için yüzen mimari yapının boyutlandırılmasında dalga-rüzgarın yapının titreşim performansına etkisinin geliştirilmesi gereken kısıtları uzman görüşü ile belirlenmiştir. Titreşim, yapı boyutlandırılması, dalga etkisinin ve rüzgâr etkisinin uzman görüşüyle yapılan değerlendirmeleri ise ürün-süreç tasarımı yaklaşımıyla yapı mimari tasarım sürecinde değerlendirilmiştir. Mimari tasarımda karar destek sistemi oluşturulurken bu yaklaşımlarla kural tabanı mantığının ana presiplerinin oluşturulması amaçlanmıştır.

Çalışmada incelenen yüzen mimari sisteminin sahip olduğu koşullar; sabit açık deniz tesislerinin çalışma koşulları olarak kabul edilmiştir. Sabit açık deniz tesisi ise; açık denizde devamlı olarak veya belirli bir süre için çalıştırılmak üzere tasarlanmış ve deniz tabanına bağlı olan, çeşitli maksatlı tesisler arasındadır. Çalışmadaki yüzer mimari tasarımın yapım sistemi; zemine gerilmeli demirleme elemanlarıyla bağlı sephiyeli yapılar (germe ayaklı platformlar) arasındadır. Yüzen mimari yapı konut amaçlı yapılacaksa yüzen ev olarak adlandırılmaktadır, yüzen ev ise; ev olarak tasarlanmış ya da bu amaca yönelik dönüştürülmüş itilerek veya yedeklenerek sevk edilen, deniz araçları olarak tanımlanmaktadır.

Yüzen yapılar yer çekim kuvvetine, elastik kuvvetlere, yüzey gerilimine, viskoziteye ve atalet momenti gibi kuvvetlere maruz kalmaktadır. Yüzen yapıya etkiyen tüm bu kuvvetlerin dinamik benzerliklerini sağlayabilecek ölçekli bir model bulunmamaktadır. Bütünsel benzerlikli bir simülasyon ise gerekli değildir çünkü sadece az sayıda baskın kuvvet yüzen yapıların dinamik tepki vermesinde etki etmektedir. Az sayıdaki baskın kuvvetlerin ise dalga ve rüzgarın yanal yük etkileri olduğu kabul edilmekte ve yüzen mimari yapılara ait hesaplamalar bu iki kuvvet üzerinden yapılmaktadır. Bu çalışmada dalga yüksekliği ve dalga boyu ile rüzgar hızının yüzen mimari yapı tasarımı boyutlandırmasına etkileri dereceleri uzman görüşüne başvurularak belirlenmiştir. Kıyı yapıları tasarım sürecindeki belirsizliği modelleme probleminde, yüzen yapıya etkiyen çevresel koşullar altında ağılıklı olarak etki eden dalga ve rüzgarın etkileri, çalışmadaki süreç şeması içinde değerlendirilmiş, ve uygulamada kullanılmıştır.

Rüzgâr hızı ile yüzer yapı su hattı üstündeki alana dik gelen rüzgarın etkilediği alanın formu arasındaki ilişki, çalışmada birinci yüzen mimari tasarım süreci parametresi olarak kullanılmıştır. Rüzgar hızına bağlı olarak rüzgarın neden olduğu yanal basıncın, su hattı üstündeki rüzgârın dik etkilediği alanın boyutu ve geometrisiyle değişimesinin, yüzer mimari yapının titreşim konforunu etkileme derecesi, uzman görüşüne başvurularak bulanık mantık sistemi ile beşe ayrılmıştır. Çalışmada rüzgar hızı ve rüzgarın dik geldiği alan ve rüzgarın dik geldiği alanın geometrik formu ve su hattı üstü yapı formundan ileri gelen katsayıların forma bağlı değişimi de uzman görüşüne başvurularak değerlendirilmiştir.Çalışmadaki rüzgar-dalga arasındaki beşerli derecelendirme, Bufor sayısı olarak bilinen, dalga yüksekliği ve rüzgar hızı arasındaki genel bir korelasyon derecelendirilmesi örnek alınarak çalışmaya uyarlanmıştır.Dalga yüksekliği ile yüzer yapı su hattı ile üst yapı yüksekliği arasındaki ilişki, çalışmada ikinci yüzer mimari tasarım süreci parametresi olarak kullanılmıştır. Yüzer yapının bordası; su ile yaşam alanlarının başladığı zemin arasındaki yükseklik, yapıya gelen dalganın dalga yüksekliğine bakılarak karar verilmesi gereken bir boyut olarak kabul edilmiştir. Çalışmada dalga yüksekliği ile borda yükseliğinin belirlenmesi ilişkisi, uzman görüşüne başvurularak yüzer yapı titreşim konforuna etkisi beşerli olarak derecelendirilmiştir. Dalga boyu ile dalga yönü doğrultusundaki yüzer yapı uzunluk oranı arasındaki ilişki çalışmada üçüncü yüzer mimari tasarım süreci parametresi olarak kullanılmıştır. Dalga boyu ile yüzer mimari yapı boyu arasındaki ilişki, yapının stabilitesi açısından kullanıcı konforunu etkileyen titreşime neden olabileceği için dikkatle ele alınmıştır. Dalga boyu ile yapı boyu arasındaki ilişki, beşerli bulanık mantık derecelendirme sistemiyle uzman görüşü alınarak değerlendirilmiştir.

Yüzen yapıların tasarım sürecindeki belirsizlikler; dalga hareketinin doğrusal olmayan etkisi, dalga hareketi ile ilgili eksik bilgi, dalganın kıyılarda kırılması, türbülans ve dip sürtünmesi nedeniyle ortaya çıkmaktadır. Çalışmada sonuca ulaşmak için; yüzen mimari yapının çevresel koşul değişikliklerine tepkisi, karar verme sürecindeki eksik bilginin düzenlenmesi, tasarım modeli mantığı içinde işleyen sözel belirlenmiş duyarlı değişkenlerin aralığında gözlenmiştir. Bu açıdan yaklaşıma izin veren araçlar araştırılarak, yüzen mimari tasarım sürecinde problem çözümü için kullanılabilecek araçlar belirlenmiştir. Yüzen mimariyi bir örnek çalışma alanı ve bulanık mantığı, dilbilimsel kural tabanlı bir karar verme desteği olarak kullanarak, yüzer mimari süreç tasarımı için bir süreç modeli önerilmiştir. Yüzer mimari tasarım sürecine etki eden yapının oturduğu zemin olan su ile ilgili doğal oluşumlar ve oluşum süreçleri anlaşılamazsa belirsizliklerin ortaya çıktığı görülmüştür. Çalışmadaki önerilen su ile ilgili oluşumların kavramsallaştırıldığı modelle, dalga ve rüzgârın oluşum sürecinin sahip olduğu değişkenlik ve belirsizliğin yarattığı karmaşık ortam, önerilen süreç tasarımı içinde geliştirilmiştir. Çalışmadaki model için süreç hazırlanırken mimari tasarım sürecindeki geçmiş tasarım süreçleri incelenmiş ve örnek alınmıştır. Süreç tasarım modelinin amacını destekler şekilde, modelin Matlab programındaki uygulamasında, yüzen yapıların geometrisinin ve boyutlarının belirlenmesinde, karar destek aracı olarak kullanılmıştır.

Rüzgâr hızının dik geldiği üst yapı alanının boyutu ve geometrisinin rüzgâr hızı ile ilişkisi, dalga yüksekliği ile borda yüksekliği arasındaki ilişki ve dalga boyu ile dalganın paralel geldiği yüzen mimari yapının eni arasındaki karşılıklı etkileşim süreci kural tabanı sistem girdi parametreleri olarak kabul edilmiştir. Bu parametreler, bulanık mantık modelinde dilbilimsel olarak değerlendirilmiştir. Hareket etkisi altındaki kullanıcı için istenen konfor hedeflerine bu parametrelerin etkisinin uzman görüşü ile derecelendirilmesi ile tasarım süreci için gerekli kural tabanını oluşturulmuştur. Dalga ve rüzgârın neden olduğu yanal yük etkilerinin yapının hareketine etkisi derecelendirilirken ise kasırgaların şiddetlerinin ifade edilmesi ve kasırganın hızı ve neden olacağı hasarın önceden tahmin edilmesinde kullanılan Saffir-Simpson ölçeği örnek alınarak bir uygulama yapılmıştır. Yüzen mimari süreç tasarımında dalga-rüzgâr-titreşim etkileri altında boyutlandırma problemine uzman görüşü ve dilbilimsel kural tabanlı karar destek sistemi ile çözüm önerisi getirilmiştir. Yüzen mimari tasarım süreci modellemesinde belirlenen kurallar, örnek çalışma alanında yapı boyutlandırmasında karar destek aracı olarak uygulanmıştır. Çaışmada önerilen model, Marmara Denizi'nin kuzeydoğusunda yer alan Kalamış'ta tasarlanan yüzen yelken klübünün yapısal boyutlarının kararında, Matlab' programı içinde kullanılmıştır. Böylelikle yüzen mimari tasarımda yeni ürün modellemesi sürecinde uzman karar destek sistemi ile bir yapı tasarlama süreci geliştirilmesine örnek verilmiştir. Model ayrıca bin adet simulasyon yapılarak Simulink programında kuralların çalıştırılmasıyla test edilmiştir. Boyutlandırma kararında kullanılcak şekilde bulanık mantık derecelendirme sistemi içindeki boyutlandırma önerileri sunulmuş, karar destek aracı olarak önerilen model son kararı tasarımcıya bırakmıştır.

1. INTRODUCTION

‘But much advantage will occur if men of science become their own epistemologists, and show to world by critical exposition in non-technical terms results and methods of their constructive work, that more than mere instinct is involved’(Poincare, 2000).

This study aims to explain reasons, methods and results of the design process for floating architecture by using floating architecture design process as the case study, using fuzzy logic as the linguistic rule-based decision support. By this way the study also tries to prove the community that instinct is not the only factor involved in design epistemology and consequently tries to change the way the design practice is perceived.

The floating architecture design process modeling is discussed within three aspects providing a framework for the shift in the way that floating architectural practices are designed and produced by focusing on three features of architectural attitude change; external aspects, internal aspects and multidisciplinary correlation of both aspects.

The external aspect is accepted as the unconventionally dynamic state of environmental conditions which are formed with the effects of wind, wave, climate change, floods, environmental disasters and extreme site conditions that challenge the designers to improve the way they approach to the design. The primary focus of external aspect is to provide an adaptive and flexible decision support tool when designing floating architectural structures within the limits of integrated environmental design process rules.

The internal aspect is accepted as considering the computational challenges used in architectural processes and integrating these challenges in product design stages consequently within internal aspect rule-based linguistic decision support tool ‘linguistically used fuzzy logic’ is used.

Multidisciplinary aspect is accepted as a task requiring several types of specialisation which in this study a multi-disciplined approach by correlating of two or more distinct fields is achieved. The first discipline is architecture and other disciplines are naval architecture, industrial engineering, coastal sciences and engineering, new product development and design.

The three aspects that are mentioned above have one issue common as they have a pure complexity. The solution to this complexity is to form a design process model based on the required parameters of design and then to make a rule-based system composed of linguistically formed rules converted to digital programming.

The benefits of this decision support system are achieving time saving and a digitally controlled design.

The new sytem has an accelerated speed in making satisfactory decisions in complex environments. The man-made decision support system operates with the speed of human mind but the speed of suggested system of this study is obtained from the quantum computers of the future.

Another issue studied in this thesis is the huge amount of unused water-related areas across the world. 70% of the earth’s surface is covered by water and for the purpose of benefiting from this 70% topography, floating buildings are necessary but constructing them is still a challenge. Thus, floating architectural design becomes an important issue in the new product development of architectural design industry.

The study focuses on increasing the number of links between water and human life style and thus, the preference for alternative living and developing techniques for living on water. With the help of the time saving effects of innovative proposed model, floating architectural design is controlled even under the unpredictable nature of environmental effects.

1.1 Objective of Thesis

‘The modeling of uncertainty is motivated by two concerns: taming the variability of external phenomena and facing incomplete information in decision processes’ (Dubois, 2009).

The architectural design process is complex and mainly composed of uncertainty. As Dubois (2009) expressed, one has to succeed in dealing correctly with the variability of external phenomena in order to model uncertainty as in the case of floating architectural design and the unpredictable nature of environmental effects and clarifying the incomplete information especially in the decision process modeling.

The environmental conditions affect the floating architecture more than land-based buildings, which are constructed according to the rules of law of gravity. This study disscusses the correlation between the requirements of floating structures and environmental effects through the logic of linguistic fuzzy rule-bases.

Thesis intends to form ‘a plausible detailed testable explanatory accounts of the cognitive processes underlying special past actions of creation – act as discovery of physical laws or artifactual forms. It is the idea that computation-like processes of a certain rather than abstract kind can serve as a powerful metaphor’. (Dasgubta,1994)

Adaptable within its environment, floating buildings are accepted as flexible mobile buildings and this flexible nature causes floating structure design parameters to focus on environmental impacts such as wind and wave induced motions. Accordingly, environmentally affected architectural designs are formed. However, the mobile nature of floating architecture leads to human biodynamic problems, which are continuously influenced by wind and waves.

The uncertainty of the environmental effects are converted to determined effects, then the possibility and the probability of these effects on vibration are calculated in a rule-based fuzzy environment using the references of gradual method of fuzzy logic. Thus, designing the dimensions of the structure without numerical calculation and mathematical formulas is achieved.

1.2 Scope

The focus of this study is the context which is set of facts or circumstances or conditions that surrounds a situation or event and helps to determine its interpretation.

In the study, the following issues are accepted as the context of thesis; floating building, water-related phenomena, naval architecture, coastal living, human biodynamics, fuzzy logic, new product modeling, process modeling, linguistic rule based systems, building information management, flexible buildings, mobile buildings, multidisciplinary works, generative algorithms, complex system design and environmental design.

In this study, floating building design and construction properties are discussed. Since floating buildings are in water and exposed to exterior conditions of wind, waves, humidity, salty water, moving living organisms and threat of moving ships apart from the land-based buildings, they should be specially treated.

Floating architectural structure resembles to a moving vehicle and is under constant effect of wave and wind induced motions causing unhealthy vibration effects and preventing the building from reaching the determined user comfort targets. Looking multidisciplinary to overcome this problem, support from various fields of engineering such as automotive engineering, aircraft engineering, industrial engineering, mechanical engineering and naval engineering can be taken. However, mobile vehicles are generally accepted as the research areas of automotive and aircraft engineering. So, user comfort target levels for floating architecture use the data gathered from those which are already specialized in the correlation of motion effects on human health in moving vehicles.

In order to achieve the determined priority task in the thesis, the following research fields; new product design, expert system design, product to process modeling, performance design, decision support systems and building information systems, rule-based design, data-driven design, fuzzy logic and computer aided design are discussed to evaluate the new product design process modeling for the floating architecture.

The proposed decision support system for floating architectural design is determined from the data in current researches focusing on fuzzy logic, computing with words and soft computing, which is a combination of fuzzy logic, neurocomputing, evolutionary computing, probabilistic computing and parts of machine learning. In the study, the foregoing techniques are simplified to achieve a better architectural decision support system for floating architecture.

Describing and modeling the complex system of floating architecture is very difficult and time consuming. Therefore, a linguistic approach introduced by Zadeh (2009), used in the thesis. The environmental constraints affecting the floating architectural process design are converted to linguistic variables and approximate rules. The advantages of linguistic approach is that we can use the rules to understand and create the approximate random environmental situations, which are too complex or too ill-defined to be done in numerical terms.

Beginning with the literature review in floating architecture field studies and continuing with expert opinions gathered, the thesis tries to convert complex floating architecture design phases into simple concept design phases.

The first phase is research for the model; the second is approach determination; the third is focusing on limit conditions of the model, the fourth is explaining tools of the model and the fifth is the application of the model.

The use of fuzzy rules as a tool for concept design process coordination and description allows designers to control the proposed specific framework that facilitates developing and computing with linguistic descriptions of actions in architectural floating design projects.

The main factor in the ultimate concept design proposal of floating architectural design process model is decreasing vulnerability level of vibration caused by wind and wave induced motion. Wind and wave induced motion is accepted as the response of floating structure to changing conditions of wind and wave and these motions cause stability problems.

The response of floating structure is disscussed with lingusitic rule-based approach and then the decision support model is evaluated. The decision support model is developed to improve human comfort problem under vibration. The linguistic variables determined with expert opinion are then evaluated with fuzzy logic within the framework of the model.

At the application phase of thesis, results obtained from the case study of 'Floating Yacht Club and Sailing School' design are presented and the linguistic rule based decision support modeling is analyzed with expert opinion within the proposed model.

The correlation of competitive and cooperative co-evolutionary algorithms are used in this study to be able to manage the uncertain search space and tackle the complex and decomposed problem of human comfort target levels caused by the wind-wave induced motion effect of the floating structure.

1.3 Method

Rapid developments in computer aided design cause increasing interest in purely informative and performative architecture and ongoing improvements in the fields of material sciences, biomimetic and algorithmic systems in particular give relatively more access to computational tools and bring more accessible digital fabrication. Consequently, amongst the generative tools, scripting environments and parametric software, the linguistic rule-based systems are used in this study to ensure that the accesibility of descriptive design process modeling come to the fore in floating architectural design.

This thesis focuses on new product development of floating architecture design process modeling, using expert opion's linguistic rule bases as a decision support.

The main properties of data used for rule-based design of floating architecture are site specific, climatic and environmental. These data-driven and rule-based techniques through initial phase linguistic process within a rule based framework enable to achieve the desired objective of human comfort targets under motion effects.

The performance and objective of the concept design phase of floating structure are modeled linguistically within the limits of the determined environmental and site-specific constraints.

The rule-based model analyzed with expert opinion provides immediate feedback and response to environmental conditions as the model correlated with external and internal data through proposed number of correlations and rules.

This method enables the architect to design not only with pure intuition but also with rationalized logic without numerical calculation but with the support of expert opinion. The thesis structure can be seen in Table1.1.

Table 1.1: The new product development flow chart of thesis.

1. Research of Design Process Modeling of Floating Architecture
2. Approaches for Design Process Modeling of Floating Architecture
• Environmental architectural design parameters
• Performance based architectural design phase constraints
• New product development in architecture
• Product to process modeling of architecture
3. Limit Conditions for Floating Architecture Design
4. Tools for Design Process Modeling of Floating Architecture
• Building information management
• Expert knowledge
• Fuzzy logic
5. Application of the model for Floating Architectural Design Process

Problems occurring within the lifecycle of small-scale floating structures are discussed and aspects that separate floating construction from land-based structures are determined. User comfort, environmental effects and structural stability and safety of floating structures are examined under linguistic terms.

In Figure 1.1, the focus design phase of the thesis can be seen as the third phase, where case-based reasoning and rule-based systems are used for creativity enhancement.

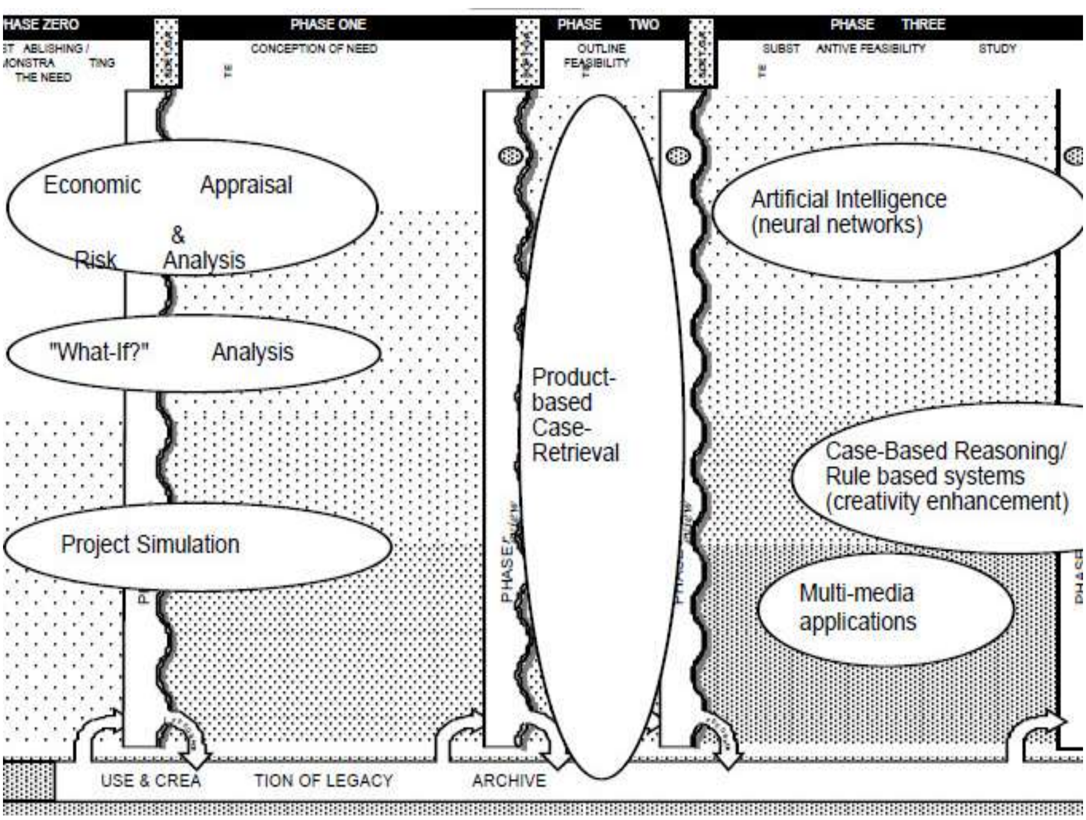


Figure 1.1 : The focus design phase of thesis (Aouad, 1998).

2. RESEARCH FOR DESIGN PROCESS MODELING

In research phase of the proposed process model for floating architecture, first of all, the importance of floating architectural modeling in the study is discussed amongst other studies that have been carried out across the world. Then the context of the floating architectural design is summarized to describe the limits of the selected floating structure type. As the final phase of the research, the proposed model focus problem and crucial phases of the solution are stated.

> Today architectural discipline is allowing the logic of digital systems to be relentlessly used in the design practice. However, we should be aware of the disciplinary significance of the import of digital media because it offers an outline of a changed cognitive attitude with the digital inscription. (Goulthorpe, 2008)

This study tries to answer the question that Goulthorpe (2008), asked in his book Posssibility of (an) Architecture; 'How do radically transforming circumstances generate new architectural forms in this period of incredible new potentials?'

Architecture makes an exploration of the limits of a medium, but now this medium is the method rather than the message. Indeed, the formats are essential to those of commercial software borrowed from other disciplines, so the integration of its import has been the only legitimate acvitity in the absence of base research in new generative schemata specific to our field. Clear insight into different digital methodologies should be evaluated in order to encourage speculative research work on digital methodology with an expression of several emergent design tendencies. Goulthrope (2008), also mentioned that 'the product of a particular ethic would come to be the challenged logic of that digital system, where architects' machine-code creavity becomes inseperable from material-substance'. Consequently, this study tries to establish floating architectural design process model knowledge in the light of the evident shift form of process from scriptual to fuzzy logic, establishing an attitude; a kind of critical creavity in floating architecture which does not rely on a specific external theory. Floating architecture is an adaptive strategy towards this sort of creativity, implying movement, transition and responsiveness, which provide an environment where the physical effects of force stimulate in a creative atmosphere. By this way working dynamic environments are formed transforming each from static to dynamic environments.

2.1 Importance of Floating Architectural Design Process Modeling

Earth moves, so has been said: origin, even, as concept, displaced by the notion of transformation. Within the whole system behaviour of transfromation Goulthorpe (2008) describes the product as one of ‘plethor of possibilities suspended as a matrix of open-ended opportunity’. And he asks “How can you verbilize a moment of creativity?”

From the prespective of Antoniades (1992), in his book ‘Theory of Design in Poetics of Architecture’, he explains this phenomena as “Architects today are too educated to be either primitive or totally spontaneous, and architecture is too complex to be approached with carefully maintained ignorance. Yet one constantly discovers during the process, realizing possibilities that may not have been contemplated before’’. Consequently, this study deals with the process design of floating architectural structures in their mobile environment within limit conditions of nature, trying to find a model to realize the design possibilities that may not have been contemplated before.

Antoniades (1992), also focuses on the role of nature in architectural creativity, ‘we have harmonious coexistence and interraction with the contours of the terrain, the orientation, the winds, the flow of water, and all the other natural constraints’ suggesting that ‘held that the nature will not reveal its secrets unless you are willing to take the time to see and study it. In the light of Antoniades’s (1992), sentence, this study discusses the complexity of floating architectural design as it involves properties of kinematic architecture affected from natural phenomena.

Johnson (2010), explains in ‘Embracing Complexity in Design’ kinematic architecture as; ‘the issue is simply to transform existing conditions into preferred ones and create a delightful artificial environment for living. Kinematic architecture is where ‘a building incorporates motion through use of dynamic technologies. So, the built environment can become more amenable and less controlling’.

Motion induced response of the floating architectural structure results from forces that affect the geometry and the entire form of the structure as well as the form that affects these forces impact levels on the structure in return. Following the same context, fuzzy logic and linguistic variables are used in this study as an application method for providing an adequate interraction between input and output parameters of the design system where each affects and is affected by the other.

Despite recent studies on fuzzy decision making, modeling and control, not much is reflected in architecture. Using fuzzy logic in this study focusing floating architectural design, the study originates from design epistomology, which refers to the study of human knowledge, cognition and cybernetics and human-machine interaction. Fuzzy logic also deals with uncertainity theories, which can be discussed in two parts. The first part is probobalistic or set valued representations and set-valued representations are discussed in this study. Using fuzzy logic as a decision support for the floating architectural design, which is under the effects of uncertain environmental phenomena, the question ‘who decides?’ asked by Moma (2008) in his book titled ‘Design and the Elastic Mind’ and correspondingly Moma’s decision metods are also discussed in this study. As every building has a limited life cycle period, the discussion in this study focuses not on buildings but the cognitive process behind them.

When architects whose focus studies are floating architecture are considered, Buckminister Fuller, known for his architectural invention of geodesic dome, stands out as one of the architects dealing with floating architectural projects. Fuller (1981), produced the dymaxion automobile as a new style mobile house and many projects related to floating cities.

Using fuzzy logic in architecture is new in Turkey, Arabacıoğlu (2008), has studies about fuzzy logic application in space analysis in architectural design. Sarıyıldız (2007), has studies at Delft University of Architecture has ‘Applied Neuro Sciences’ Deparment, which studies on the relationship between fuzzy logic and architecture.

Product to process design model types are also discussed in a large number of studies in research field of architectural designs.

Berkel (2006), discusses in his book titled ‘Un Studio / Design Models’ the design models used in architecture and their meanings, which are one of the focus topics of this study. Their meanings are compiled in a document containing a set of requirements and goals, formulated for the purpose of reducing the range of options for applications.

The focus of this study is on outdoor space and it is a problem driven design. It can be architecture that derives its character from changing combinations of its surrounding environment as much as from its form.

Fuzzy logic is a subfield of artificial intellegence and knowledge, representation, learning, planning and qualitative reasonning are discussed in detail in this study. This will challenge conventional perspective of an architecture. Arabacioglu (2008), Cebi (2010) and Kahraman (2010), Kaymak (2002), Satir (2010) as well as Sen (2010) conducted studies on fuzzy logic under different study fields in Turkey.

In addition, Olthuis (2010), carried out studies on floating architectural design, disscused the issue widely within his book ‘Afloat’. Prominski (2012), conducted a recent study on water-related design in European rivers with a book ‘River. Space. Design’.

Akın (2002), asks in his study titled ‘an exploration of the design process’ “Can we describe the land over which an architectural structure is founded only in words? Consequently, Akın (2002) states that ‘under non-gravity conditions, we have not only total connectivity but also total inconnectivity’. In this study, land over which a building is founded is accepted as a variable, which changes and gives different forms to the building. Additionally to Akın (2002), in this study a new type of process is proposed solely for the purpose of providing a path to users to connect with landscape.

Heller (2008), discussed in ‘Design Disasters’, ‘if we could be aware of all narratives that we are going on rather than we think to be the right narrative, anything could happen, any space could happen and any story could happen’. Heller (2008) declares; ‘failure occurs when big picture is ignored’. Consequently in this study the big picture of floating architectural design process model is discussed without underestimating the complexity of floating structure’s behaviour under motions of the determined landscape as water.

The buildings were once studied as materialized drawings, but they are now increasingly materialized within digital information; the number of design decisions according to the scale of the project and the ratio of added design content to added constructed content. If entering many commands and parameter values to a computer-aided design system is sufficient to generate a great deal of construction content, then the project is of high complexity. To minimize the complexity, standardizing the spatial relationship among them is needed (Flachbart, 2005). Since the quantity of information increases, the numbers of decisions increases. Thus, a tool for decision support is needed.

Oosterhuis (2002), declares that 'designing with rules, algorithms and a running process pave the way for a new kind of building. These buildings are based on the behaviour of an intelligent flock of swarming points, each of them executing a relatively simple rule, each of them acting according to 'the local awarness of their immidiate environment'. The outcome of this process can be a class of simple rules generating complexity. So, in this study, the building is connected as a running processes, not designing through computation, it is accepted as a computation. For this new kind of building paradigm, simple rules generate complex results. Furthermore in this study, fuzzy logic is used to reference intellegence of human, which is an awareness that emerges from the bottom up through a process of evaluation by building relations between nodes of the system.

Intellegence also accepted as an emergent behaviour coming up from the complex interractions between less complex actuator. It therefore, works according to a simple set of programmed rules to form a complex consistent structure. The means of the results can be seen only after running the system. So this study suggests designers to set up systems and run them in order to perform by admitting that simple computations like fuzzy logic applications translate complex behaviours.

The objective of the thesis is to create the type of building environment that supports living on move with water by exploring the concept of floating architecture as a way of flexible living.Pure research is used to develop a sampling technique that can be applied to a particular situation and develop a methodology to asses the validity of the proposed procedure.

As Kumar (1999) states, the knowledge to be obtained through this research is required to be added to the existing knowledge of research methods. The type of information sought is quantative, which describes the variations in a phenomenon, situaton and attitude to examine the feasiblity of conducting a study. By this way the problem is formulated.

This study includes a cognitive system based on fuzzy information processing with a multi-objective algorithm. It also aims at integrated product and process design evaluation through product realization process (Mahgrap, 2010).

The performance based design is one of the field study of aerospace architecture, which investigates the limits of structure performance, safety, durability and repairability focusing on required performance levels.

Rijken (2006) is a researcher in the field of floating structures and has a Ph.D degree on floating structures.

In his Ph.D thesis, Graff (2009), discusses floating urban life in its every aspect.

Ciftcioglu (2009), conducted studies in the field of Design Informatics in Delft Architecture Department that is specialized in ‘Applied Innovative Neural and Fuzzy Systems. Ciftcioglu (2009), staets that ‘Human decision maker is setting the criteria and computations provide optimal solutions for these criteria, the decision maker modifies the criteria based on these solutions until a pareto-optimal solution matches the designer’s complete preferences as far as possible’.

Kolarevic (2008), discussed kinetic and dynamic design in ‘Architecture in the digital age: design and manufacturing’, furthermore also working on the idea of manufacturing materials, effects, rethinking design and making in architecture and the new methodologies apart from the standart building techniques.

Eastman (1999), has conducted numerous studies in computerized architecture, who also works in the field of ‘product to process systems and their applications in architecture found (Georgia Tech Process to Product Modeling, GTPPM)

Kalay (2004), also conducted studies in cognitive design strategies. These design strategies are also dicussed widely this thesis. However great importance is given to the correlation of shape and the use of fuzzy controlled parameters.

In this study there is no restriction even on the number of variables, however three objectives with five degrees of variables are considered, where each solution is equally valid, provide the decision maker a variety of alternatives. In this manner, the alternatives can be explored by these determined varying parameters.

This study also discussed emerging technologies, robotics and control systems, advanced research and in cybernetics, finally fuzzy computing with words is used.

Considering the limitless possibilities of completely flexible buildings, the thesis tries to alineate itself from conventional approaches to architecture where most users of architecture are accustomed to an architecture that is essentially composed of static and solid objects.

The modeling process parameters of floating architecture of this thesis are environment-related; have user-oriented building design patterns and include dynamics of flexible nature of floating architecture.

The modeling process intention of floating architecture is to achieve optimum adaptation to changing situations of environment and user comfort. The behaviour pattern of adaptation discussed in thesis is motive rather than static and tries to adapt rather than stagnate and transform rather than restrict, and interacts with the changing atmosphere.

The intention of making a new design process modeling tool for floating architecture is to create an environment that automatically responds to user-oriented comfort requirements, forcing adaptability of the design modeling process parameters to act more flexibly.

The floating structures research studies are consequently conducted for mostly very large floating (VLF) structures such as floating airports, stadiums, gas platforms and bridges.

In Figure 2. 1, a flow chart can be seen as an example for a floating bridge, where wind and wave are taken as dominant characteristic parameters in the calculations of floating architectural design process modeling studies.

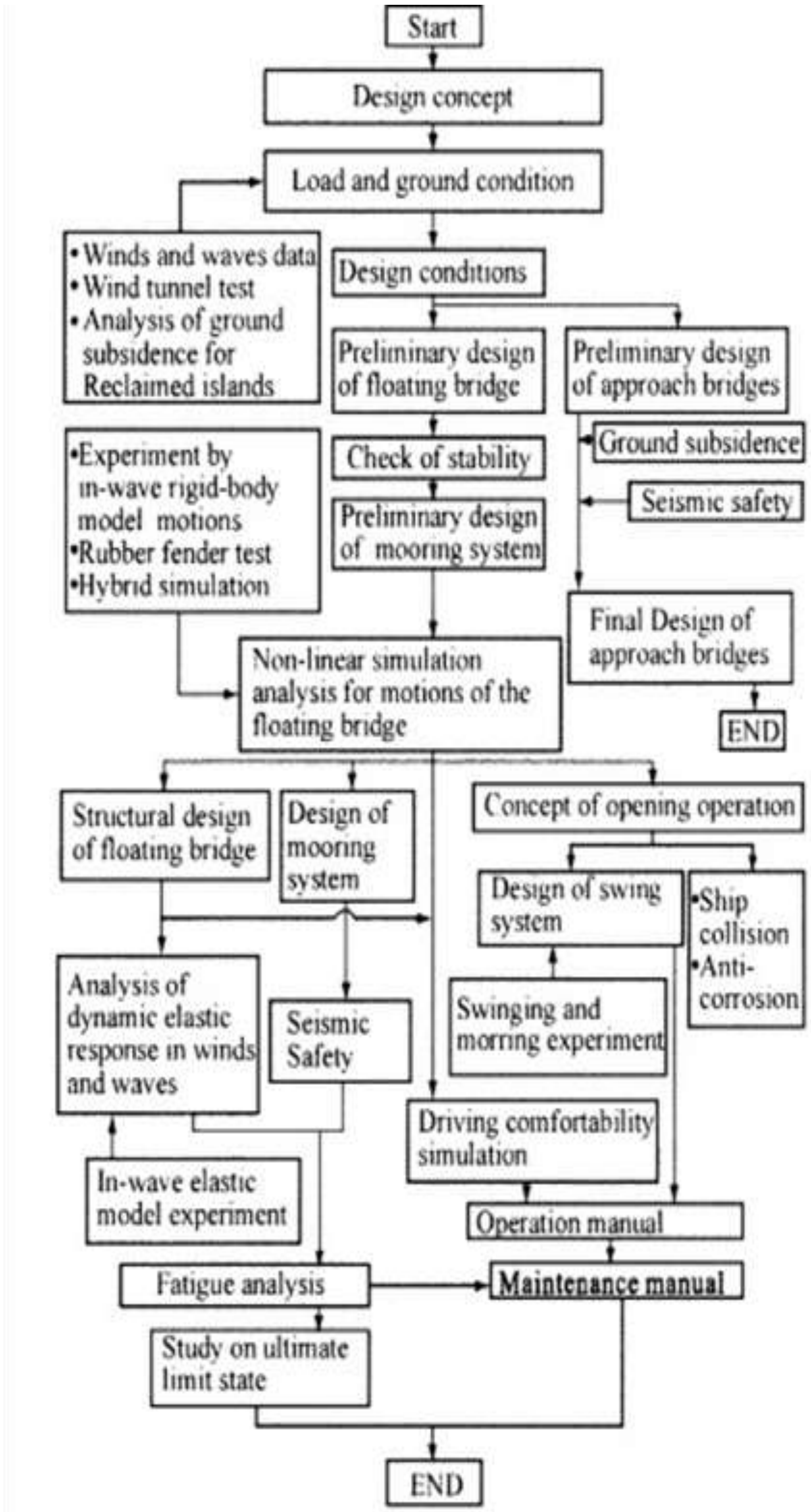


Figure 2.1: Flow chart of Yueshima-Maishima Bridge (Watanabe, 2000).

The ultimate design modeling process proposed for floating architecture in the thesis may be a process that is completely amphibious and transitional, changing position, as a human being moves through it, abandoning flat horizontal surfaces with vertical motions and demarcations between hard and soft, warm and cold, wet and dry. In this way, the new model for design process of floating building can create an architectural design style like an installation with constant changing performances.

Delta download areas all over the world face problems of flooding confronted with urbanization, climate change and scarcity of space as similar to Netherlands. In these areas floating and amphibious urbanization provide an opportunity for multi-functional use of space. Any damage to the construction is not expected to occur because floating houses will quickly adapt to the rising water level. Their flexible, reversible and relocatable nature contributes to the adaptive capacity of floating houses and they can serve as emergency shelter during flooding.

Many important engineering issues such as dynamic response to wave, wind, earthquake and vehicle loads should be projected in floating architecture modeling design process to satisfy the above-mentioned purposes. Floating architecture is the focus because ordinary buildings will be difficult or economically infeasible for such new purposes as it can be concluded from the literature study.

The rule-based decision support system developed for floating architecture design modeling process is the purpose of this thesis, evaluated and accepted as the first kind of study in the world, using linguistic rules for decision support sytem that focuses on the optimization process of user comfort target level changes caused by motion.

The rule-based linguistic design process model is evaluated by worldwide studies that have been carried out in the field of fuzzy logic. In Figure 2. 2, research project of Design Informatics Delft University of Technology, Design Informatics; a designer explores the Pareto-front and modifies the criteria in an iterative manner can be seen. The progress made in fuzzy logic in architectural design encourage researchers to study in this field. The uncertain nature of floating construction and design leads to model the process with fuzzy linguistic variables.

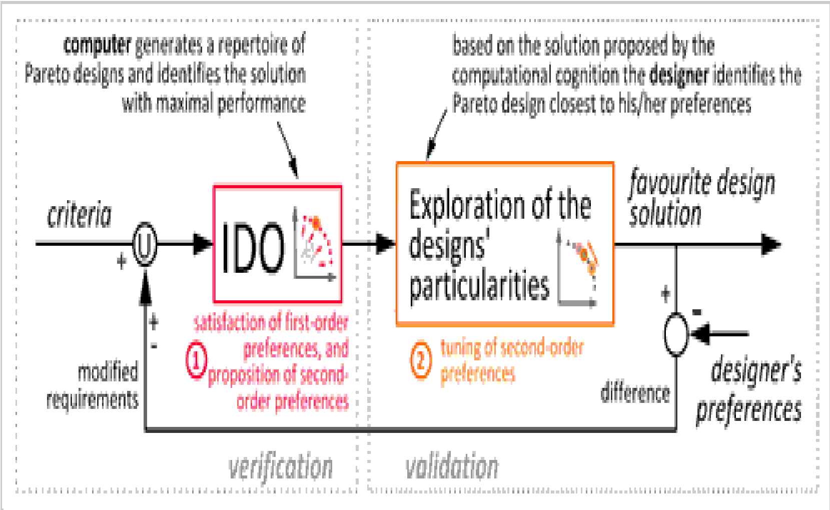


Figure 2. 2 : Cognitive approach to performance-based design (Ciftcioglu, 2009).

2.2 Floating Architectural Design Context

Floating architecture is a flexible and reversible mode of urbanization and responds to the social purpose of increasing the capacity of the adaptation of the built environment to climate change and has recently drawn great interest of researchers, politicians and media in countries such as Netherlands, Canada, Japan and USA.

Architects try to design experiences and users of designed spaces are encouraged to have their own experiences within their own particular climates. As a design subject, floating architecture can be accepted as a programmable building body that can be evaluated according to determined environment parameters.

Before starting out for our work of the thesis, contemporary architecture was wrongly accepted as a discipline of intractability. Today buildings are mostly meant to be steady as a rock and more importantly resistant to flow. The study configures buildings that can float and move with changes during use more than it was considered possible before. They can move in line with changing conditions. Then architecture will become dynamic and more flexible with the entire building. In this way, architecture will be able to move in philosophical terms. Superstructure movements and characteristics can be seen in Table 2.1 and six movements of floating vehicles are shown in Figure 2.3 to highlight the importance of movements in the design process modeling of floating structures.

Table 2. 1 : Superstructure movements and characteristics.

Superstructure Movements	**Movement Characteristics**
WAVE	OSCILLATION
TIDE	RISING-FALLING
CURRENT	DRIFTAGE
WIND	SUPERSTRUCTURE LOAD RESISTANCE and THE FLOATING PART TRANSFERS LOAD
COLLISION/ ACCIDENT	RESISTANCE TO THE ACCIDENTAL COLLISION and RETURNING TO THE INITIAL POSITION
EARTHQUAKE	TSUNAMI AND LOAD TRANSFER

The literature review on the need for floating environments especially indicates the high speed of population growth and increasing demand of people to live near or around watersides or within the limits of water environments.

The world population is expected to double from two billion to four billion in the next 30-35 years. According to UNFPA, rural and urban population is equal in global scale, in 2007. The urban population is expected to double in the next 35 years. The proportion of people living in cities to rural population is expected to increase up to 50% in 2030. (Graaf, 2009)

Urbanization predominantly takes place in coastal and river basins that are exposed to flood risks. Climate change and sea level rise issues will increase the vulnerability of delta areas. The increase in flood damage will significantly and directionally form new urbanization designs and parameters. Mostly identified 150 measures to reduce vulnerability of urban areas include wet-proofing and dry proofing of buildings and infrastructure, building on mounds, building on stilts, constructing a higher freeboard between road and floor level, flexible and removable constructions, amphibious housing and floating urbanization. One of the suggested solutions is the floating architecture, which is the focus of this study, intends to stay on a certain location and to connect the construction to underground with mooring construction. (Graaf, 2009)

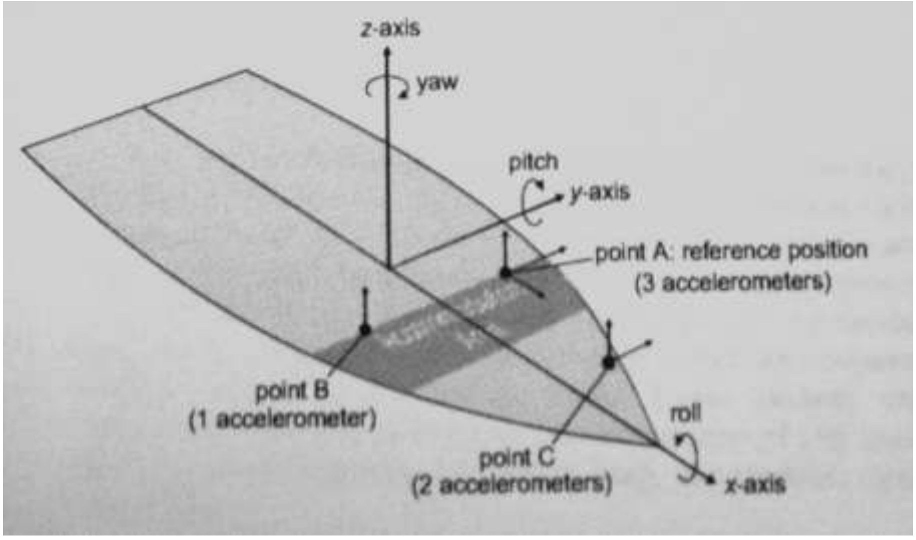


Figure 2.3 : Six movements of floating structures adapted from (Griffin, 2009).

Floating architectural design should include environmental awareness approach. It should a shift from ‘fighting with water’ to ‘ living with water’. The topic of thesis is a direct result of this new approach.

2.3 Problem Context in Design Modeling Process for Floating Architecture

Human beings are flexible creatures. We move about at will, manipulate objects and operate in a wide range of environments. There was a time, not too long ago in evolutionary terms, when our existence based on our capacity for movement and adaptability; indeed it is to this that we owe our survival as a species.

The importance of flexibity in architecture is stated by Kronenburg (2007). Most cultures now live a more or less sedentary life, but it could be that flexibility is once again becoming priorty in human development and that technological, social and economic changes are forcing or at least encouraging, new form of nomadic existance based on global markets, the World Wide Web and cheap fast transportation. However, there are some weaknesses of the floating architecture such as disadvantages of its mobile nature, a high risk of polluting water related environments and effects of wave and currrent motions.

After all, there is a risk of bearing the superstructure even after the construction is over and furniture should be designed according to the mobile nature of the building. Human biodynamic constraints and comfort targets, which are affected by vibrant nature of floating architecture, should be arranged to preserve human health. Factors such as accident risk, regional tsunami or tides require immediate solution. The mooring system needs to be designed acccording to ground properties and the load transfer is the most important design problem, making the floating design a complex design that needs more expertise from naval architecture and structural engineers. In Table 2.2 problems in load transfer and the causes can be seen.

Table 2.2 : Problems of load transfer and causes.

Problems in load transfer	**Causes**
superstructure	wind, accidents, snow, rain
floating construction	chemical properties of water, wave, current, weight of superstructure, gravity center of superstructure
mooring	chemical properties of water, wave, current, weight of superstructure, weight of floating part, gravity center of superstructure and floating part
anchors	chemical properties of water, wave, current, weight superstructure, weight of floating part, gravity center of superstructure and floating part

One of the most important problems of floating architecture is its juridical status, which requires mortgages, insurance and building permits.

‘The PRC company in Netherlands prepared a new guideline covering topics such as buoyancy, stability, wave movement, freeboard, tilting, safety in case of collision with vessels, fire safety and emergency’ Graaf, (2009). Such guidelines have already been prepared in Canada. In Table 2.3, some examples of the approach of reverse buoyancy criteria, static stability and damaged stability from design standards for floating homes in Canada are listed.

‘Protection of coastal environments is an important issue for island nations such as Taiwan, particularly because more than 90% of population resides in coastal regions. Marine structures such as seawalls, caissons, and offshore breakwaters have long been utilized in these types of regions to protect residents from the actions of ocean waves. One such marine structure is the detached platform. However, ensuring the stability of these marine structures is a complex problem. Structural instability induced by resonant motion must be consired during design. (Chen, 2009)

Table 2. 3 : Design standards for floating homes in Standards Canada.

Reserve Buoyancy Criteria
The floatation device shall have sufficient buoyancy to support the lightship weight of the float home plus the maximum combined weight of deadweight items and design snow load and maintain a minimum freeboard of 200 mm. The floatation device shall maintain a minimum freeboard of 400 mm under normal load conditions (the above noted loads minus design snow load).
Static Stability
The floatation device shall have sufficient stability in both the longitudinal and transverse directions to limit the amount of trim and heel resulting from wind forces to a maximum of one half of the freeboard at rest or 5 degrees, whichever is less. This can be established by application of a wind heel criteria as follows:
GM = PAH W tan (T) where P = 0.028 tonnes/sq meter A = projected area in sq meters of the portion of the float home (floatation system and superstructure) above the waterline H = vertical distance in meters from the centre of "A" to one half the draft T = 5 degrees or the angle of heel at which one half the freeboard is immersed, whichever is less.
Damaged Stability
The floatation device shall be subdivided by watertight bulkheads, have integral floatation material or employ alternate methods of limiting the ingress of water such that in the event of damage to any two adjacent compartments, the minimum freeboard of the floatation device after damage is not less than 100mm at any point. The initial load condition for assessing damaged stability shall represent the maximum normal load of the float home, but excluding snow load.

Following juridical status, vibration is another problem that should be considered in design process of floating structures where performance specifications has a special intensity, especially on the effect of vibration and motion induced response of the floating structure. Human biodynamics is affected from vibrations caused by winds, waves and load transfer resistance of floating architecture. The solution to vibration problem is to adapt the design to changing external conditions. The control and adaptation of architectural design can be achieved by controlling the process of structural safety of the construction under regular and extreme loading conditions caused by variable changes in wind and waves.

The most important issues particularly affecting human biodynamics and biokinematics comfort are investigated and vibration is found to be the most effective of all as a threat for human health. What follows these values is the Maslow's pyramid of needs as in Figure 2.4 where body physiological needs and security safety needs are taken in this study as prior dominant requirements that should be met under the consistent effect of motion induced loads in floating architectural structures. Some of Maslow's (1943), pyramid of needs are stated as:

• Body (Physiological) Needs such as air, warmth, food, sleep, stimulation and activity. This need concerns biological balance and stable equilibrium (homeostasis). These needs can be very strong and if a person is deprived of them for far too long, the person will die.

• Security (Safety) Needs such as living in a safe area away from threats. This level is more likely to be found in children since they have a greater need to feel safe.

• Social (Love and Belongingness) Needs such as the love of family and friends.

• Ego (Self esteem) Needs such as healthy pride. The Ego needs focus on our need for self-respect, and respect from others.

• Self Actualization (Fulfilment) Needs such as purpose, personal growth and realization of potentials. This is the point where people become fully functional.

(Ercoskun, 2006)

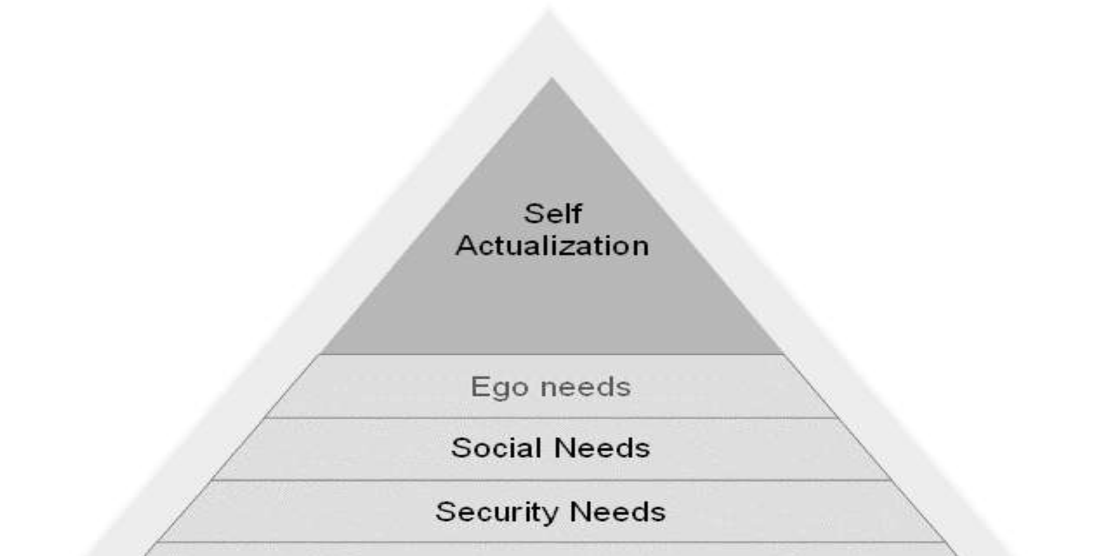


Figure 2.4: Maslow's pyramid of needs (Maslow, 1943).

In Table 2.4, the symptoms seen in a crew working on a ship are discussed in study of Griffin (2009). Colwell (1989), Pethybridge (19282), Crossland (1994), Powell (1998), Stevens (1990) and Wertheim (1997) also studied in effects of vessel motion on human performance, seasickness incidence in royal navy ships, made experiments to quantify the effects of ship motions on crew task performance. All can be summurized into motion sickness and biodynamic problems as human factors in naval environments. In the study of Griffin (2009), the ship is on the move for six months under motions with directions of x, y and z axis. Headaches, dizziness, tension and anxiety and depression are some symptoms seen, showing that user comfort target levels are very important for the health of users. The health hazards caused by the motion of floating structure are accepted as the most important aspects to be discussed in this study. A model for solving this problem is evaluated in the following chapters.

Table 2.4: Symptoms under the effect of consistent motion (Griffin, 2009).

SYMPTOMS
HEADACHES
DIZZINESS
TENSION/ANXIETY
STOMACH AWARENESS
NAUSEA
VOMITTING
SWEATING
FAINTNESS
ACHES/PAINTS
LOW BACK PAIN
MOTIVATION
DEPRESSION

Adaptation of floating structure to environmental effects without changing structural integrity of the floating system is achieved by consulting detailed expert opinion and knowledge from previous literature survey. The axioms are used to form a rule based design process modeling of new product development of floating architectural design with linguistic approach.

From the standard performance specifications in Table 2.5, the 'comfort' performance specification and 'prevention of vibration' are taken as design objectives of the floating architecture design process model in the study.

Table 2.5 The standard performance specifications (Warszawski, 1999).

1. Health and safety
• *Structural safety under regular and extreme loading conditions* • *Structural safety during fire* • *Prevention of health hazards*
2. Serviceability and Use
• *Furnishability and Organization* • *Operational realibility of mechanical systems* • *Prevention of sensible deformations and vibrations*
3. Comfort
• *Provision of comfortable hygrothermal conditions* • *Prevention of vibration and acoustic disturbances* • *Provision of adequate lightening*
4. Preservation of Property 5. *Aesthetics*

In the study, the user comfort vibration parameters of floating structures under consistent dynamic effects of sea conditions are discussed with expert opinion as to form a rule-based approach for evaluating design model process. In Figure 2.5, evaluation of solutions and trade-off goals are stated.

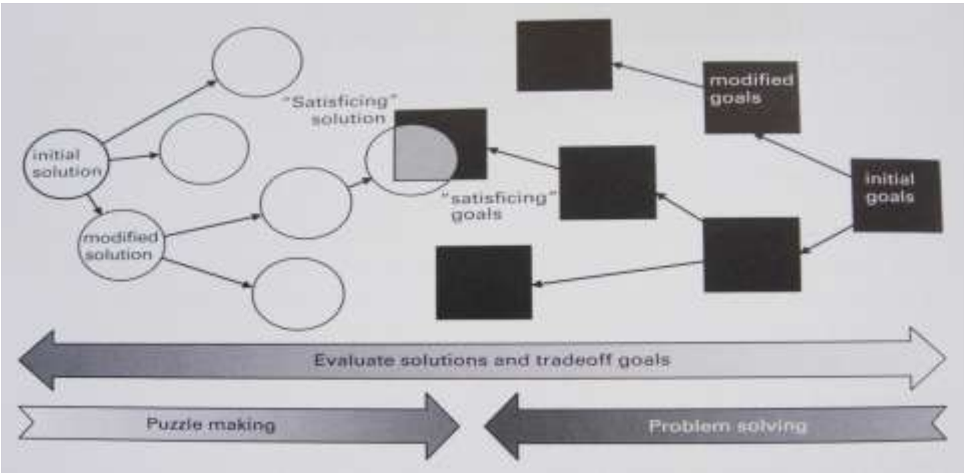


Figure 2.5 : Design as a dialogue between goals and solutions (Kalay, 2004).

Rule bases are used to control wave and wind specific parameters correlated with structure-specific parameters to reach the desired user comfort-specific parameters. In this manner, converting initial goals to satisfying goals to solve the problem of motion is achieved.

In the concept design modeling of floating architecture, the consideration of performance specifications are not so different from other architectural designs, however there are special focus areas such as motion induced vibrations. Human biodynamics is affected from vibrations caused by winds, waves and load transfer resistance of floating architecture. In Table 2.6, vibration standards are given to emphasize that prevention of vibration is the most important objective of the process design of this thesis. The solution to the vibration problem is to adapt the design to changing external conditions. The control and adaptation of architectural design can be achieved by controlling the process of structural safety of the construction under regular and extreme loading conditions by variable changes in wind and waves.

Table 2.6 : Vibration standards and salient features.

Vibration Standards	Salient Features
VDI 2056/1964 [5,6]	It is a German standard developed on the basis of Rathbones's [3] work. It is intended for use with overall level measuring equipment, which allows only these components of the signal within the frequency range 10 Hz to 1000 Hz to pass.
BS 4675[7], ISO 2372 [8,9], ISO/IS3945 [6]	These standards are identical to VDI 2056.
Indian Standard 4729 [5]	These are applicable to rotating electrical machines with power ranging from 0.15 kW to over 1000 kW.
In all the above standards measurements are expected to have been carried out by seismic transducers [5] on the bearing caps or structures of the rotating machines	
IRD Mechanalysis [4,6]	The standard is laid on the peak to peak velocity in mm/sec for all categories of machines and does not give standards that can encompass the entire range of speeds and loads.
ISO 3945 [5]	It is based on ISO 2372 and defines the rules for evaluating the vibration performance of large prime movers and other large machines.
CANADIAN Government Specification. [8,10]	Canadian government specification [5,7] covers frequency range of 10 Hz to 10kHz but here the standards are defined for gas turbines, pumps, electric motors and so on.

In Table 2.7, superstructure motion characteristics and causes can be seen and all of them are discussed in the study with expert opinion. Wind and wave induced motions are taken as the main design parameters for the proposed design process modeling of floating architectural structures.

Table 2.7 : Superstructure motion characteristics and causes.

Superstructure motion properties	**Motion causes**
ground induced motions	properties of ground material (corrosion) load transfer situation accidents
mooring induced motions	properties of ground material (corrosion) load transfer situation accidents current, wave, wind
cable induced motions	properties of ground material (corrosion) load transfer situation accidents current, wave, wind
current induced motions	load transfer situation mooring, cables, construction form
wave induced motions	load transfer situation mooring, cables, construction form
wind induced motions	load transfer situation mooring, cables, construction form
extreme conditions induced motions	all

2.4. Research Findings

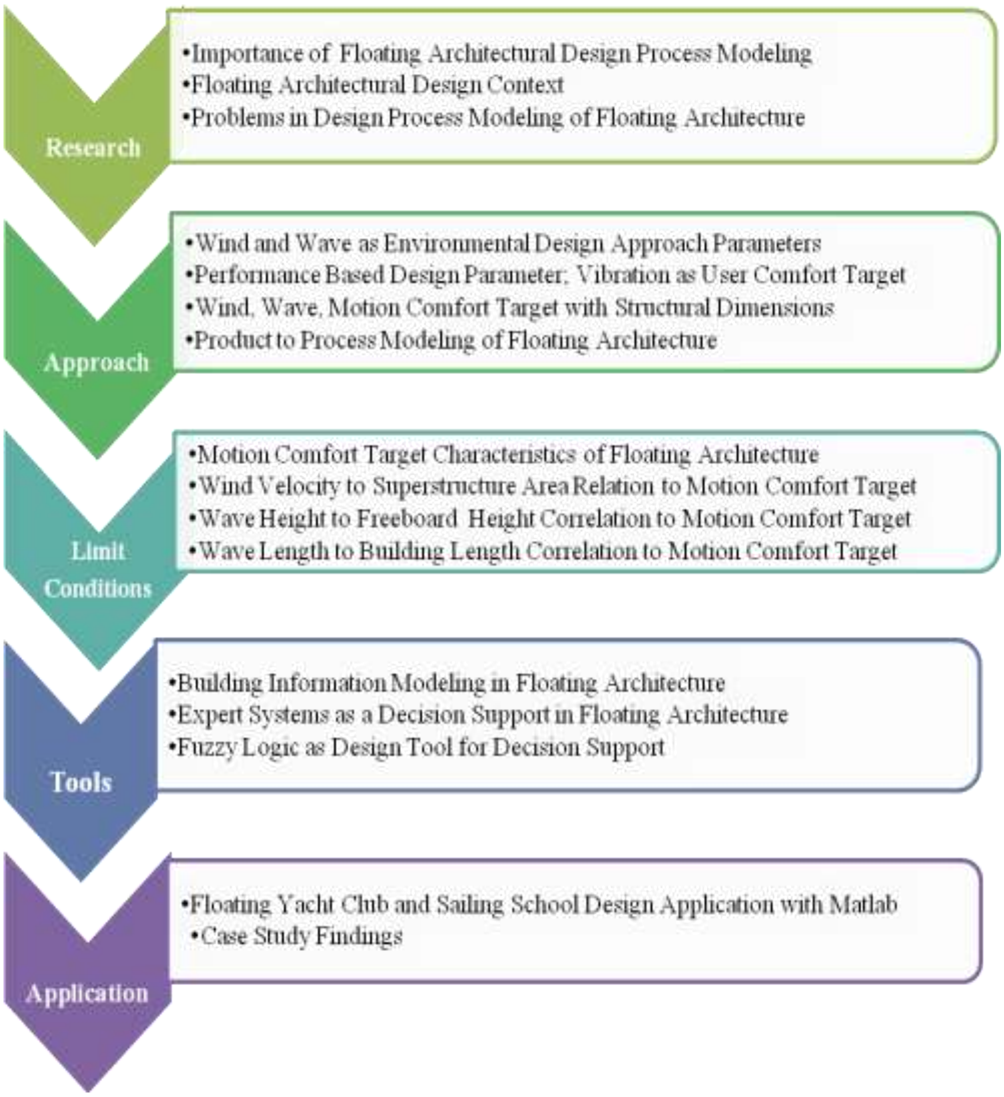
In research phase of this study and after literature review, different significant levels of floating architectural design process modeling are discussed.

The context of floating architectural design is stated and consequently, the problem context in design process modeling for floating architecture is determined and comprehensively explained in the following phases of the study.

As described in Table 2.8, the process steps of the thesis following the research phase are determined to solve the complex problem of ensuring the stability of floating archtitectural structure.

The foresaid approaches studied under architectural discipline are: environmental design, peformance based design, new product development and product to process modeling. Then limit conditions are defined and tools for the process model are specified. The proposed model is applied in a case study in Matlab program and the model is discussed within the conclusion phase.

Table 2.8 : Process steps of thesis following the research phase.



3. APPROACHES FOR DESIGN PROCESS MODELING

In the research phase, approaches for dealing with water-related phenomena are discussed and four basic approaches determined based on the knowledge acquired from the research phase are stated in Table 3.1 to be used in the study. The first approach is environmental architecture, because parameters such as wave and wind are dominant factors that form motion induced loads that eventually affect user comfort target levels in floating architectural structures. The second approach is performance based architecture, because the objective of the study is to prevent health hazards as the model improves user comfort vibration levels. The third approach is product to process model approach after discussing environmental variables under the performance based approach since the need for a process model is evident. The fourth one is new product development approach, which embraces environmental, performance and product to process approaches under the objective of linguistic rule-based decision support model of the study.

Table 3.1 : Approaches for floating architecture design process modeling.

environmental architecture	• wind and wave motion effects
performance based architecture	• user comfort vibration
product to process models	• research phase, approach phase, limit conditions phase, tools phase, application phase
new product development	• wind, wave, vibration correlated with structural dimensions

3.1 Wind and Wave as Environmental Design Approach Parameters

'Architecture always depends on things that are already there, it involves recognizing their potential or the problems they present, it involves remembering their association and acquisition of significances, thus it involves choice of site and sharing with others' (Antoniades, 1992).

As Antoniades (1992), declares and after the research step of this study, it can be stated that floating design process also depends mostly on the things that are already there such as wind and wave.

In the environmental design approach phase of the study, wind and wave effects and their potential and relevant problems are presented. The discussion in the study involves consideration of the relationship between environment and design process and their significances. Thus, the study context involves selection of site and sharing the characteristic properties of the site with designers.

In Figure 3.1, among the effects of wave induced motions that cause underflow, sway, heave, roll effect is stated so as to give an example for the dominant characteristics of wave induced motions influcing the design process of floating architectural structures.

> Architecture also involves building the physical alteration of a part of the world to enhance or reinforce its establishment as a place. Choice and recognition operate the rudimentary levels of identification of place. Architecture makes more difference when it proposes and puts into the physical effects of the environmental changes to the fabric of its own design world. (Antoniades, 1992)

> Fundamentally, all terrestrial architecture depends upon the ground for its base, something that is taken for granted. In a flat and completely featureless landscape, the establishment of a new architectural design will have to be an arbitrary decision, however the characteristic properties of the site may also be similar to a catalyst within the design process. Simeon the Stylite can be a good example for the type of architectural designs using environmental conditions as the prior catalyst for design process. Simeon the Stylite lived in a cave dwelling within one of volcanic cones of the valley of Goreme in Anatolia. The caves were extended and refined by carving into the rock. Another example may be African baobab trees having thick trunks and soft wood. With space carved out inside, they can be made into dwellings. And also the dome of the rock in Jerusalem is built over a rock which is sacred to Jews, Christians and Muslims. In the untouched landscape, doing architecture can involve using hills, trees, rivers, caves, cliffs, even the breezes from the sea: things said to be

‘provided by nature’. Dealing with the properties of the site, the study tries to take advantage of the site, mitigate their effects and exploit their character. (Antoniades, 1992).

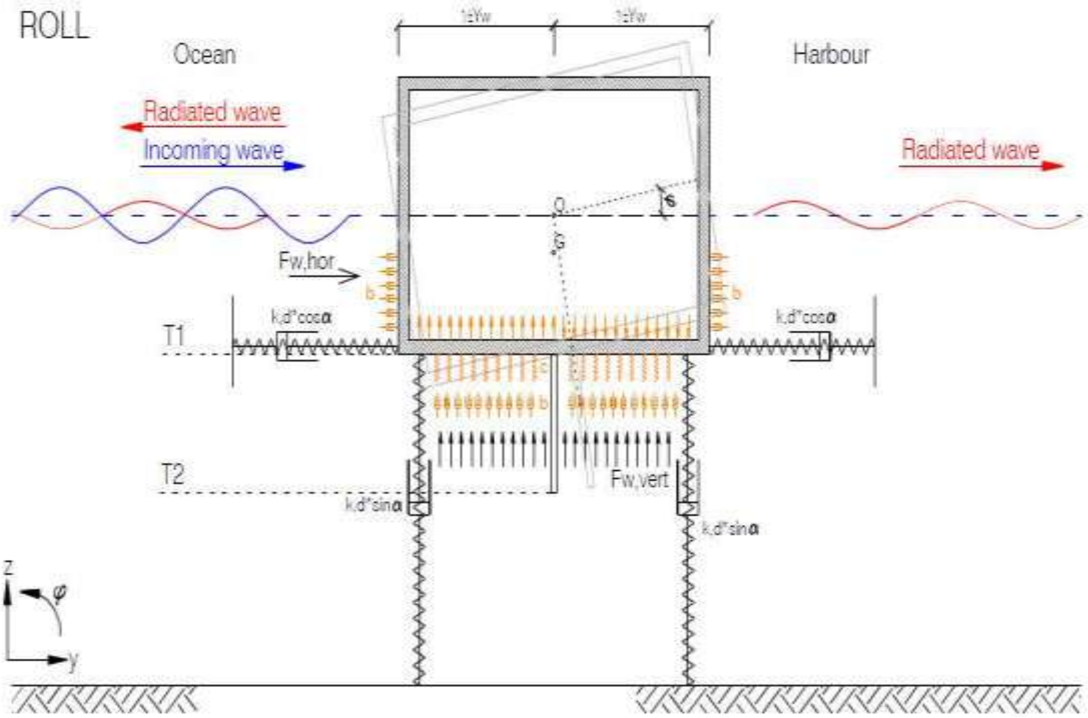


Figure 3.1 : Motion types for breakwaters - roll (Fousert, 2006).

Using natural things that already exist in a site is an ingredient, which has been termed by Alexander (1979) as ‘timeless way of building’. As such, it is as relevant today as ever, ‘one is less likely to have the opportunity to use natural features and elements in regions around the world, which have been inhabited for many centuries, and more likely to have to relate to previous products of architecture’.

Examples in which natural features or elements contribute to architecture are innumerable. However, there seems to be a transformation in the used space. The transformation of space is evident in altered caves, flattened or extended roofs.

Unwin (1997) says ‘generally speaking, while carrying out architecture, one has to deal with all or some of the following aspects’ given in Table 3.2. The designing mind may adapt different attitudes under different circumstances to each or all of these aspects. However, in the study, wind motions, wind velocity due to atmospheric conditions of weather and water motions and wave are taken as the ground for floating architectural design process.

Table 3.2 : Environmental parameters adapted from (Unwin, 1997).

The ground, with its earth, rock, tree, its stability or instability; its changes in level, its dampness, its flat or unevenness
The gravity and its consistent verticality
The weather including snow, breeze, rain, wind, lighting
The materials available for building as stone, wood, glass, plastics etc
The sizes of people as their reach, their movement, their eyes, etc.
The bodily needs and functions of people, and maybe other creatures, for warmth, security, air and food
The behavior of people, individually or in groups, social patterns and political structures
Other products of architecture (other buildings, places) that already exist.The pragmatic requirements: the space needed for various activities

In the main frame of the study, great emphasis is given to environmental architecture and it is taken as the focus area in determining the parameters for the design of floating architecture modeling. It is not only a generalized mapping of the topologically optimum spaces for the location of floating houses, the study is arranged in a manner that gives priority to vibration effects on human comfort as a design criterion. However, seeking optimal locations, existing site-specific considerations and the placement algorithm are taken into consideration. Thus, a conflict between preferred design criterion and preferred site conditions may arise and should be resolved. Environmental factors are summarized in Table 3.3.

Table 3.3 : External factors affecting floating construction design.

External design factors	Floating construction properties
wind, collision, snow, rain	atmospherical conditions
weight of superstructure and weight of floating part center of gravity and building form	structural properties
chemical water characteristics and biological water characteristics, wave, current	water properties
mooring parts, cables	mooring properties
ground characteristics	ground properties

There are many types of buildings, which are built according to environmental constraints, and some of them are solely shaped by nature. As a way of protection from flood and as a way of living near the water, the requirements of floating buildings for the maintenance of the building depends on environmental facts. As a result, floating nature of architectural design considerations are under the effect of environmental conditions.

The site where the building is located is in water and statically, it is under the effect of aerodynamic loads such as atmospheric changes and temperature changes, which eventually affect the load transfer of the building. In concept design of floating structures, these forces become the most important parameters that should be discussed in detail.

In this study, the rule-based decision support model is constructed upon environmental condition changes that cause dramatic instability in the building system, becoming hazardous for users to live healthily due to vibration effect. Thus, the most important concern of the thesis will be the effects of wind and waves and their relatively great effect on the load transfer of the entire building behavior. The objective of the decision support system will be designing a building that is adaptive to uncertain changes of environmental conditions.

3.2 Performance Based Design Parameter: Vibration as User Comfort Target

Design for performance describes a generative approach toward fulfilling qualitative and quantitative design requirements based on specification. The term design applies to the architectural domain whereas the term "performance" includes aesthetic, quantative, and qualitative behavior of an artifact. In achieving architectural quality while adhering to measurable criteria, design for performance has representational, computational, and practical advantages.

In Table 3.4, methods for performance based design are listed.

Table 3.4 Methods for performance-based design (Schmidtt, 1992).

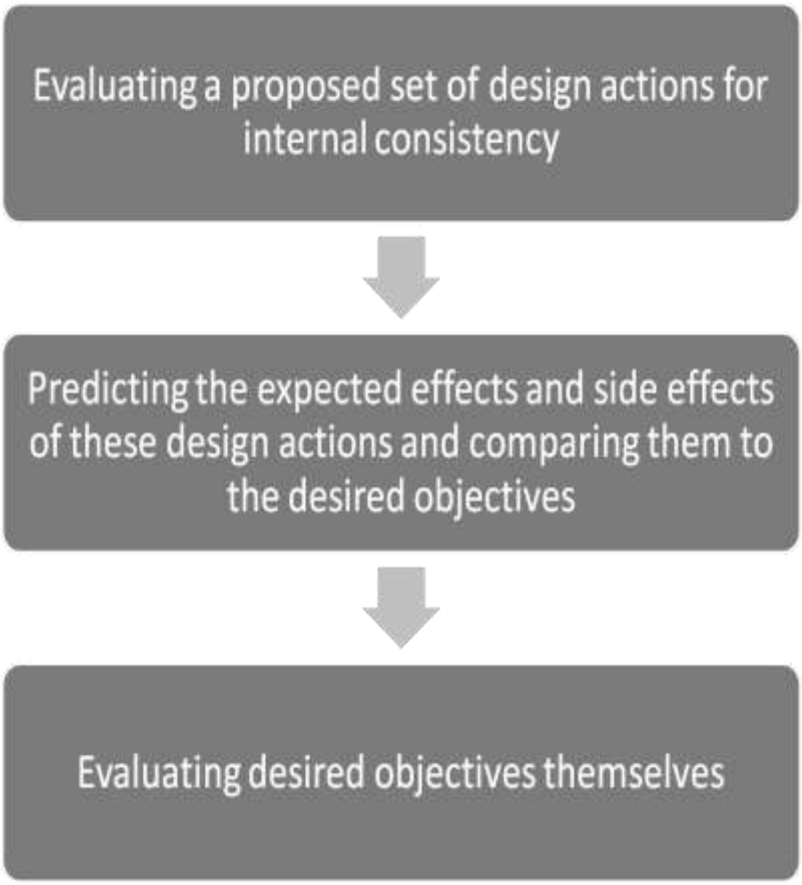
Constraint-based reasoning
Specification-driven design
Case-based planning

In this study, 'the consept for design for performance is the performance specifications defined as goal–oriented requirements concerning the behavior of an artifact' Schmidtt, (1992). Amongst construction performance factors such as temperature, light, air quality and motion effects on human biodynamics, vibration factor is discussed in the proposed floating architectural design process model

Predicting and evaluating the expected performances of design actions and the objectives aim to achieve comprise three distinct yet related tasks. In Table 3.5, the actions for performance design are summarized.

The performance-based design of floating architecture is designing the constraints of performance according to the requirements of the floating building system. The rule based decision support system will simplify the performance system and constraints and provide a solution to the vibration problem of the system.

Table 3.5 : Actions for performance design (Kalay,1992).



In the study, amongst many factors such as site, environment, technology and resources, site is accepted to be the main constraint and among safety, health and comfort, user motion comfort target level is accepted to be the main domain. Site driven comfort domains arranged with the qualitative notion is expressed in linguistic terms and their attribute of requirements are framed such as gradual limit levels.

A five-degree vibration- user comfort model is evaluated and developed to provide a design decision suppport tool for floating architecture design under motion effects. Major motion effects contributing to the observed dynamic response behaviour are designated as the relationship of length, width, lateral area and freeboard dimensions and their correlations with wind and wave specifications.

Severe wave and wind motions limit a human’s communication skills and his ability to operate, command, control, navigate and perform routine maintenance. These are completely physical limitations on gross and fine motor skills affected by the adverse effects of heavy atmospheric and sea condition changes.

In the thesis, knowledge of water-floating structure interaction and its potentially deleterious effect on the quality of the physical activities of its users are considered as a tool to reach an improved floating architectural design process modeling. Consequently, these issues are discussed with experts and a new design process method is evaluated aiming to improve the incorporation of the human element in the future of floating architectural structures.

Motion sickness is a response to real or apparent motion to which a person is not adapted. It is a normal response to an abnormal environment. Malaise, general discomfort, sweating, nausea and vomiting characterize motion sickness. Gay, (1954) described motion sickness as a ‘physical state that developes in human beings when they are subjected to oscillatory movements over which they have no control’.

The effectiveness of biodynamic models and the manikins strongly relies on representative biodynamic responses of the body. The need to identify the range of biodynamic response of the human body to vibration was identified over 2 decades ago. The ISO-5982 (1981), ISO CD 5982 (1993) and ISO-7962 (1987) standards have proposed driving-point mechanical impedance and seat-to-head transmissibility (STHT) magnitude and phase characteristics of the human body based on the averaging of various data sets reported by different investigators. Rakheja, (2010)

Whole-body vibration may affect subjective comfort, productivity and in worst cases, impair health and safety. Although there have been methods determined by humans for rating the severity and defining the limits of exposure to whole-body vibration, none has been universally accepted. So, in the study for the rating and defining the vibration levels seen in floating structures with linguistic quantitative variables, expert opinion and knowledge are used, requiring multi-disciplinary support.

An attempt should be made to reduce the levels of extreme motion to which the user is exposed and this can be achieved by altering the design characteristics of the floating structure such as developing a correlation between superstructure area and wind velocity and length and freeboard height of the floating structure with wave parameters in the design process modeling concept phase within in the proposed model so as to minimize exposure to acceleration.

3.3 Wind, Wave, Motion Comfort Target with Structural Dimensions

The new product development is an emergent approach in the consideration of a new kind of architecture, especially for floating architecture process design modeling. Ribbens (2000) states importance of new product developmet in manufacturing applications. Eastman (1999) has numerous studies about new product development, product to process systems mostly in architectural design applications. Brawne (2003) evaluated architectural thought in design process studies. Consequently, new product development of floating architectural design is a challenge in a world where 70% of the earth is covered by water and should be considered an important tool to be used in architectural design process of floating structures. Evaluating new practices in new product development and process systems in architecure is an urgent need as Fry (2009) states even more important for the future of architectural design in floating structures.

In Figure 3.2, in the new product development process schema, the first action is accepted as determining the idea or the need. The idea or need in the study is forming a correlation within wind-wave induced motion effects and structural dimensions.

Figure 3.2 : New product development process schema (Cooper, 2005).

In the research field of human biodynamics, the response of the floating structure to changing environmental conditions triggered by wind and waves is emphasized since it is the primary factor causing vibration. The focus of the design process model of the study is to achieve satisfactory user comfort levels in vibration as well as determining the optimum dimensions for the structure. In this manner, specific requirements of floating architecture process design modeling are satisfied and human comfort constraints for vibration are improved to the required level of motion effects on human health.

This study aims to discuss the new product development of pre-design phase of floating architecture. Figure 3.3 shows the predesign phase focused in the study. Both Stage A : inception and Stage B : feasibility are considered important phases that are used as initial phases in determining the concept design of floating architecture. For the inception design, the problem of vibration, which is hazardous to human biodynamics should be eliminated. The elimination is achieved by forming lingustic rule-based decision support design modeling for purpose of ruling out the uncertainty of behaviour of the floating construction under environmental conditions.

Pre-design	A B
Design	C D E
Preparing to build	F G H
Construction	J K L
Post-construction	M

Stage A	: Inception	Stage B	: Feasibility
Stage C	: Outline proposals	Stage D	: Schema design
Stage E	: Detail design	Stage F	: Production info
Stage G	: Bills of quantities	Stage H	: Tender action
Stage J	: Project planning	Stage K	: Operations on site
Stage L	: Completion	Stage M	: Feedback

Figure 3.3 : Riba plan of work (Cooper, 2005).

3.4 Product to Process Modeling Floating Architecture

The objective of the thesis is to propose a new process design modeling for floatng architectural structures based on product to process modeling approach.

> We want to surprise our audience we want to show what we can. Do with the current resources here and now we also want to surprise ourselves in the design process. Artificial intuition our motto was and still is. We must train our intuition to direct our logic. (Oosterhuis, 2002)

'Characterized by discovery, learning and judicious decision making, the design process resemble to explanatory search, where alternative courses of action are hypothesized and their effects are predicted and evaluated against the prefined set of desired conditions' Kalay, (1992).

> The task of creating a development process is never completed. Once we have designed the process we need to change it to keep up with changes in the environment. This process improvement will only occur if we attempt to learn from new information generated by the development process itself. Importantly, this is not for information about the product, but rather information about process. (Reinertsen,1997).

As Steinitz (1990), stated the types of models are representation, process, evaluation, change, impact and decision models. In the study, the focus is on the correlation between the process models and the decision models. The proposed model in the study is a process model that is designed as a decision support.

The following questions are adapted from the work of Steinitz's (1990) model types;

- REPRESENTATION MODEL: How should motion affect floating architectural design process?

- **PROCESS MODEL**: How should the motion effect on user comfort in floating architectural design process be described?

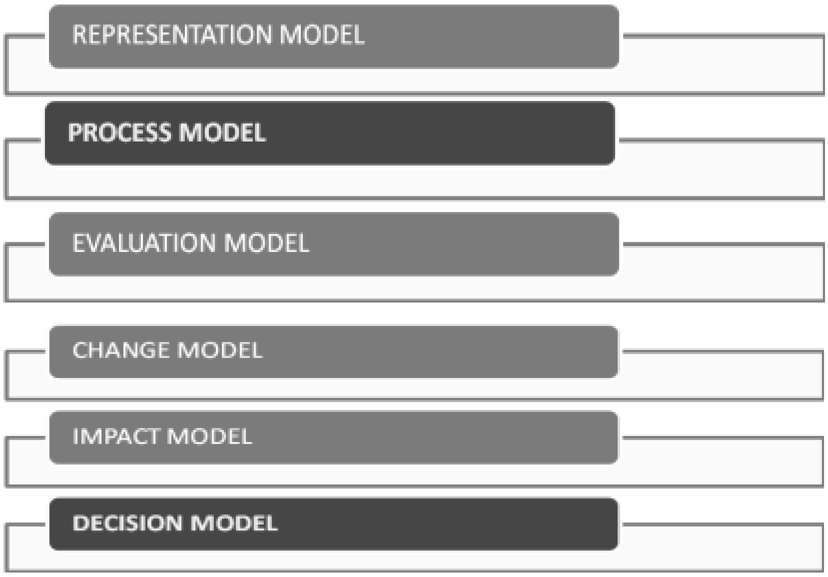
- EVALUATION: How does the system run under motion effects?

- CHANGE MODEL: Does integrated system that is subject to wave and wind effected motions perform well?

- IMPACT MODEL: How can the floating architectural design process be altered? What differences will these changes cause?

- **DECISION MODEL**: Should the design process be changed under the determined level of constraints?

Table 3.6 : Model types (Steinitz, 1990).



A model is a mathematical or a physical system, obeying specific rules and conditions, behavior of which is used to understand a real physical, biological, human-technical, etc. system to which it is analogous in certain respects.Miller (1995), studied design process primer for achitects, supporting designers evaluate ther own construct process model. However, for the ‘construction product’, ‘process’ thinking is not as commonly used as in other fields of manufacturing and producing. ‘In order to deliver a high quality and safe ‘construction product’ on time and in a cost-effective manner, it is important to manage the process and its problems effectively’ Cooper, (2005). Mileta (2009), worked in product realization and its evaluation through comprehensive studies with a generative product approach.

In the study, both the safety of the product and the process are discussed in detail and especially their effects on the user’s health, which turns out to be one of the most critical issues when selecting a new life style such as living in floating architectural structures. Not only the design but also the logic behind the designing process are discussed highlighting the cognitive thinking of a designer dealing with the problem of new product modeling of floating architectural design.

Incorporating cognitive characteristics seems untouched; so, the architectural design process is aimed to be improved in the study by using rule-based decision support system with fuzzy logic.

3.5 Findings about Approaches

In this study, the floating architecture design process is discussed under the proposed model steps including research, approaches, limit conditions, tools and application, which are applied in concept design phase to simplify the intense complexity.

The required data for each phase is obtained from the literature review of the thesis research phase, and approaches are selected to determine the method to solve the focus problem of the thesis issue.

The following step is the tools step, where design tools are used to support the evaluation of the proposed design process model of the thesis. In Figure 3.4, the proposed process schema of the study can be seen.

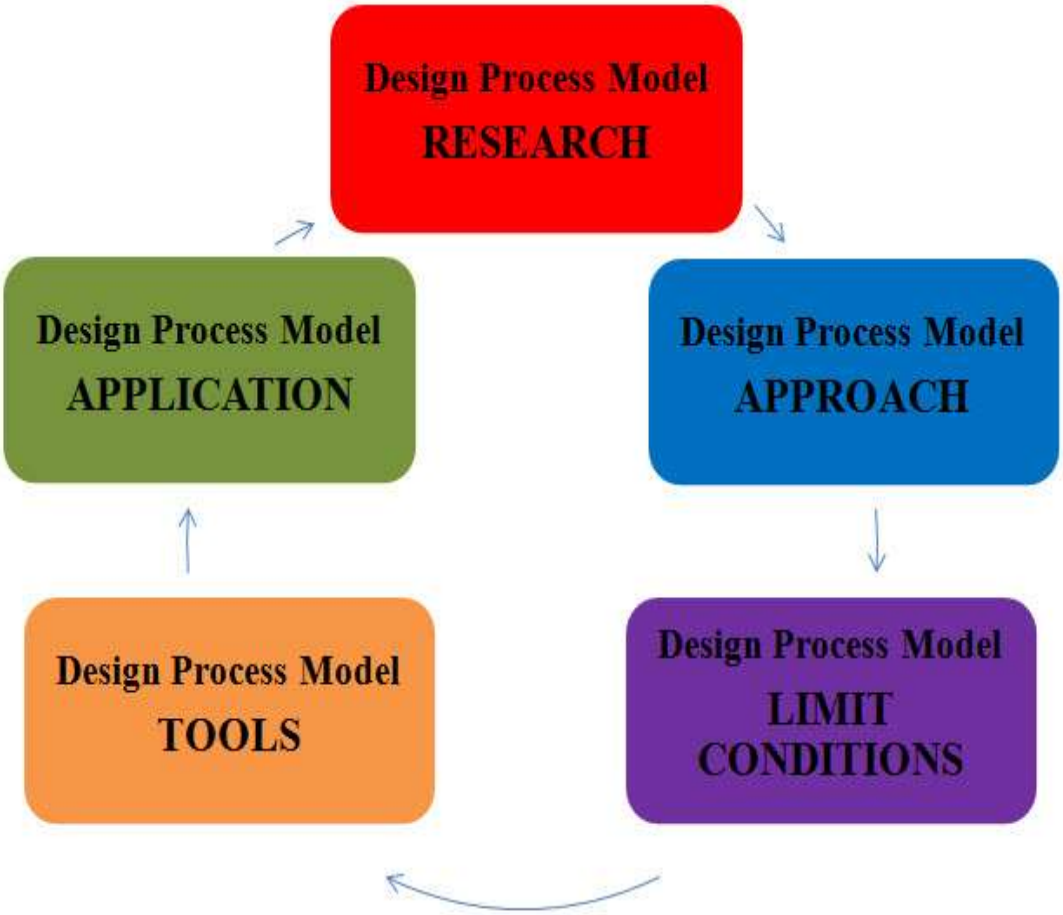


Figure 3.4 : Process schema of the study.

'The increasing sophistication and variety of product functions and consumer values have made design work more complicated' Ichida, (1996). The recently accepted complexity is a serious field in the scientific research area especially in multi-disciplinary context. Ocean engineering, coastal engineering, computing, naval architecture, finance and architecture are some areas with complex nature. However, clarifying the complexity is a very serious task to achieve. The dominant complexity of the design of floating structures is decreased as four design approaches are used in the determination of the thesis: wind-wave motion effects are studied under the environmental approach, user comfort target levels are studied within the performance based approach and model steps are formed using product to process approach . These process steps are stated in Figure 3.4 in Process schema of the study. Furthermore wind-wave induced motions which are correlated with structural dimensions are studied under the new product development approach.

One of the major problems of mobile and flexible buildings is vibration, which is discussed in performance approach. The problem occurs when the floating structure responses to motions. The relation between the motion and the user comfort target levels is discussed with expert opinion and then rule-based decision support tool is used to generate product to process modeling, which is evaluated in the new product approach of this study. Figure 3.5 summarizes the requirements schema of the thesis, which is generated within the new product development approach.

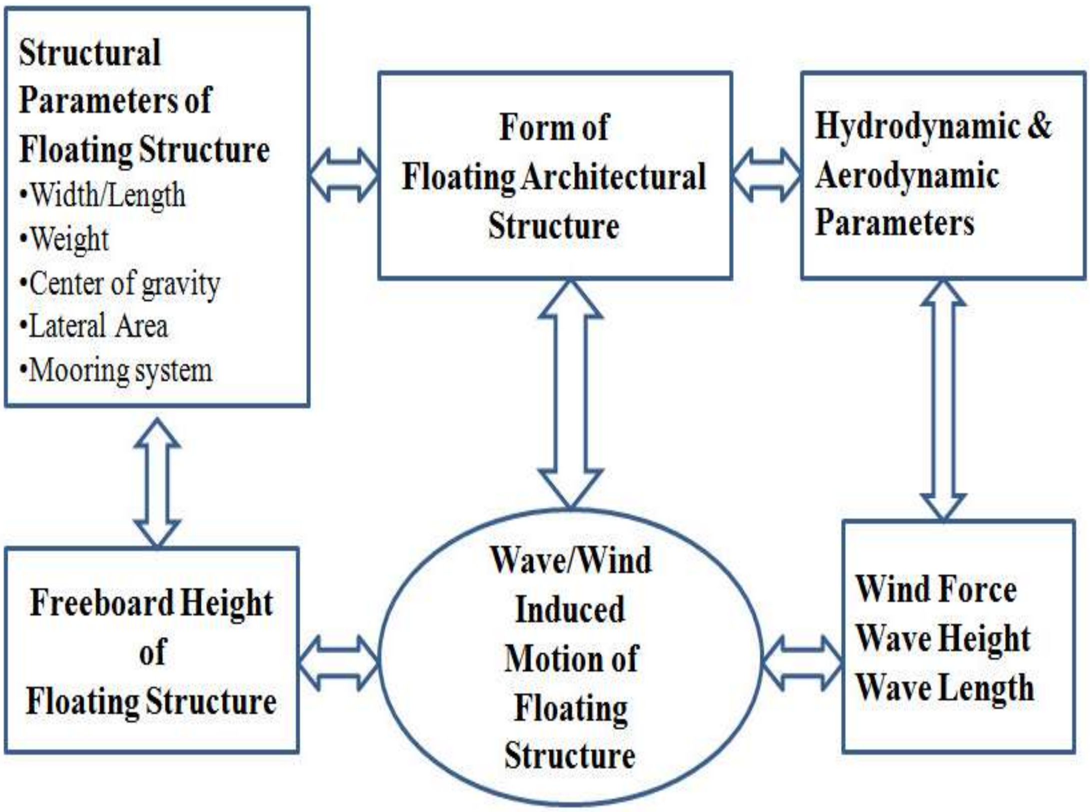


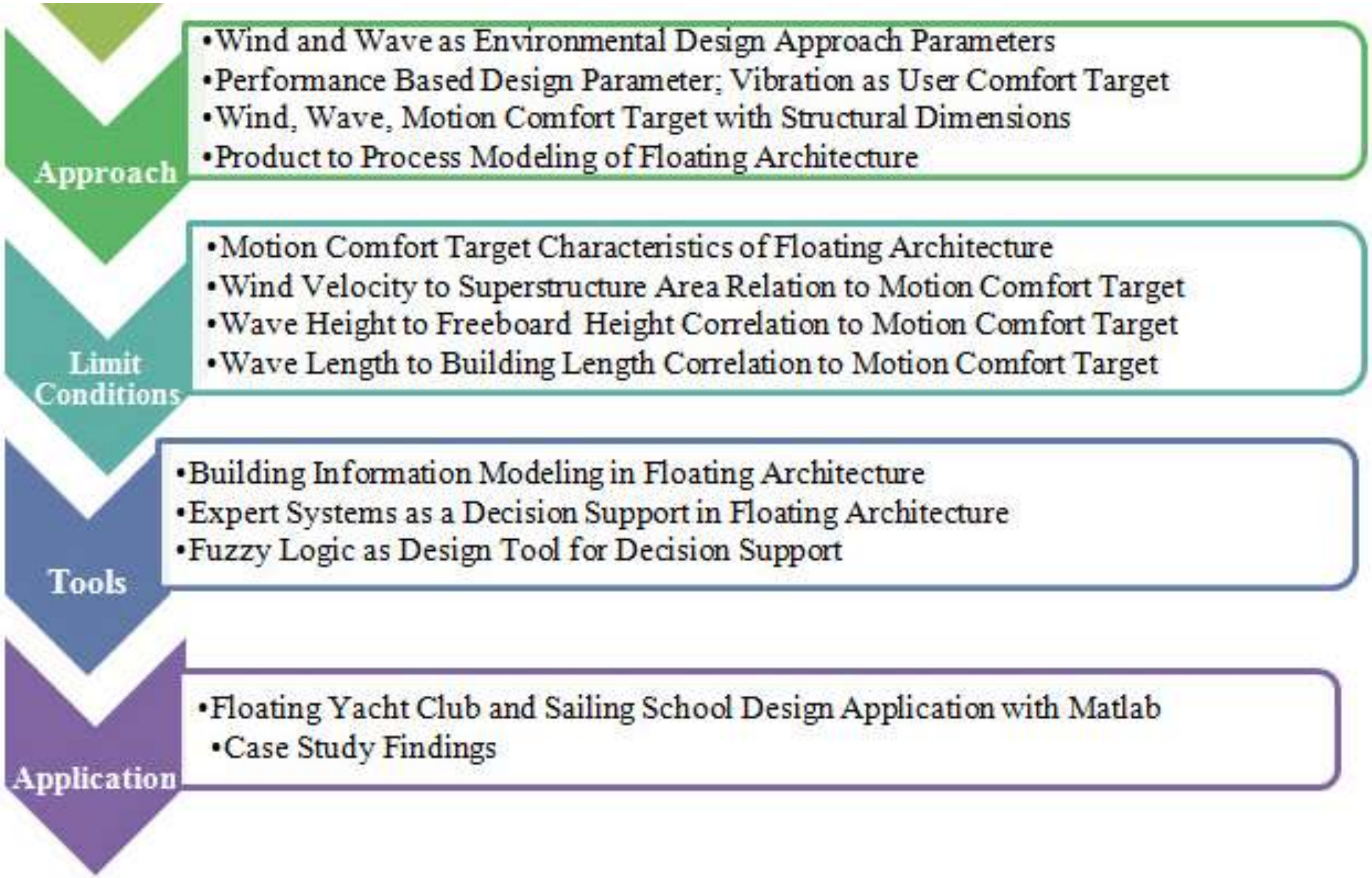
Figure 3. 5 : Requirements schema of the study adapted from (Fousert, 2006).

This study is a proposed experimentation of a new field focusing on different approaches. The study's approaches give the designers the ability to design with pre-defined parameters.

The possibility of determining the dominant motions effects on the form of the structure is disscussed in the approach phase. In the following step, the limit conditions are discuseed in full scale. As determined in the new product development approach and product to process approach, the limit conditions are stated, where these new digital tools are used for unprecendented precision from design to production.

In Table 3.7 the process schema of the thesis following the approach phase can be seen. Following the approach phase, in the limit conditions phase, reassessment is made in the relationship between the designer and the limit conditions of the floating structure.

Table 3.7 Process schema of the study following the approach phase.



4. LIMIT CONDITIONS FOR DESIGN PROCESS MODELING OF FLOATING ARCHITECTURE

In the limit conditions phase, the concern of the floating architecture design process modeling is to give specific emphasis to floating structure’s environmental conditions that affect the geometry and dimensions of the structure. Consequently, due consideration is given to the identification of wind-wave based uncertainties that increase with environmental condition changes, within linguistic variables.

Design is all about problem solving and finding solutions for why something cannot be done in a certain way. What is most important is the knowledge, which is sought in this study through solving new set of problems of floating architectural design process modeling using building information management approach.

The fundamental issue in design today is the lack of care behind a design product. It is the care that goes into designing and defining the idea that is important. A product such as floating architectural structure is a completely technologically sophisticated and complex one. It relies on huge expertise in so many different areas. However, the major part of this study focuses especially on simpler concepts. Once the process is comprehended, it will be simply joining the dots. The question is ‘Do we need or even want the most sophisticated information to design a floating building?’ Relatively simple expressions for various concepts are sufficient to succed in embracing the whole design process model. However, in this study, floating product is initially preferred to be conceived through re-inventing purpose of its usage.

Floating product is affected from environmental issues, it is accepted in the study as an inspiration for making the design process but in unexpected ways. Trying to use the disadvantages as a catalyst for good design, wind-wave induced motions affecting vibration are used as a decision support for deciding structural dimensions of the floating base and geometry of the superstructure. Expert opinion is relatively used because time should be invested to understand the set of problems and just an expert has the ability to creatively make assumptions to solve problems.

4.1 Motion Comfort Target Characteristics of Floating Architecture

A system is formed of inputs, outputs and interractions that affect a certain physical process. Among finite parameters, dominant input parameters and output parameters and their interractions that affect the physical process of floating structures are determined in the limit conditions phase of the study. ‘The motion comfort target characteristics of floating structures are affected mostly from the wave and wind induced motions’ Chen, (2009). It is especially necessary to consider all motion vibration system behaviour that affect the design as well as all systems constraints that are affected by the design. In Figure 4.1, floating architecture design system constraints under the effect of motion are summarized as key words.

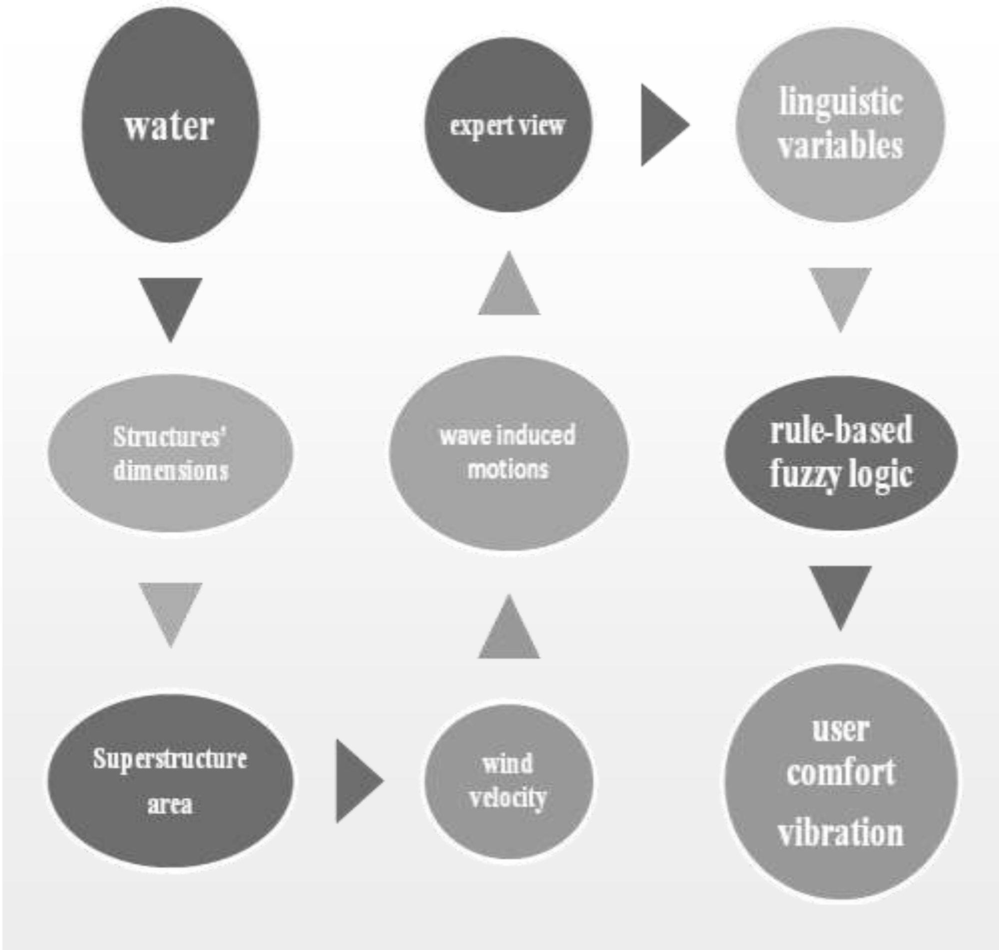


Figure 4.1 : Model constraints under the effect of motion.

In this study, a rule-based solution system is used to provide a fuzzy logic model for a water-related environment, in which wave and wind induced flow fields cause structural motion. Secondly, optimum user comfort vibration levels are determined with expert opinion. In Figure 4.2, design requirements for floating breakwaters can be seen under a schema of a ‘correlation of calculation parameters, design properties and boundary conditions and requirements’ Fousert, (2006).

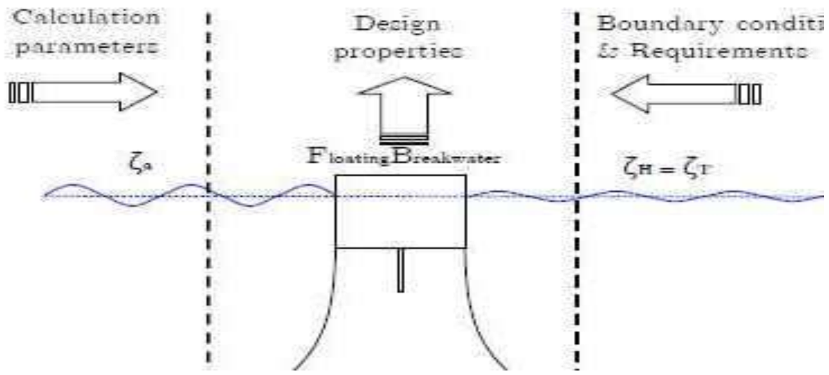


Figure 4. 2 : Design requirements of floating breakwaters (Fousert, 2006).

Succesful design of the floating architectural process involves consideration of environmental conditions. Limit condition phase of the study presents the limit conditions that affect the proposed design process model. In Figure 4.3, limit conditions in the context of floating architecture structures are summarized. These limit conditions are used in the model in the context of floating architectural design process requirements.

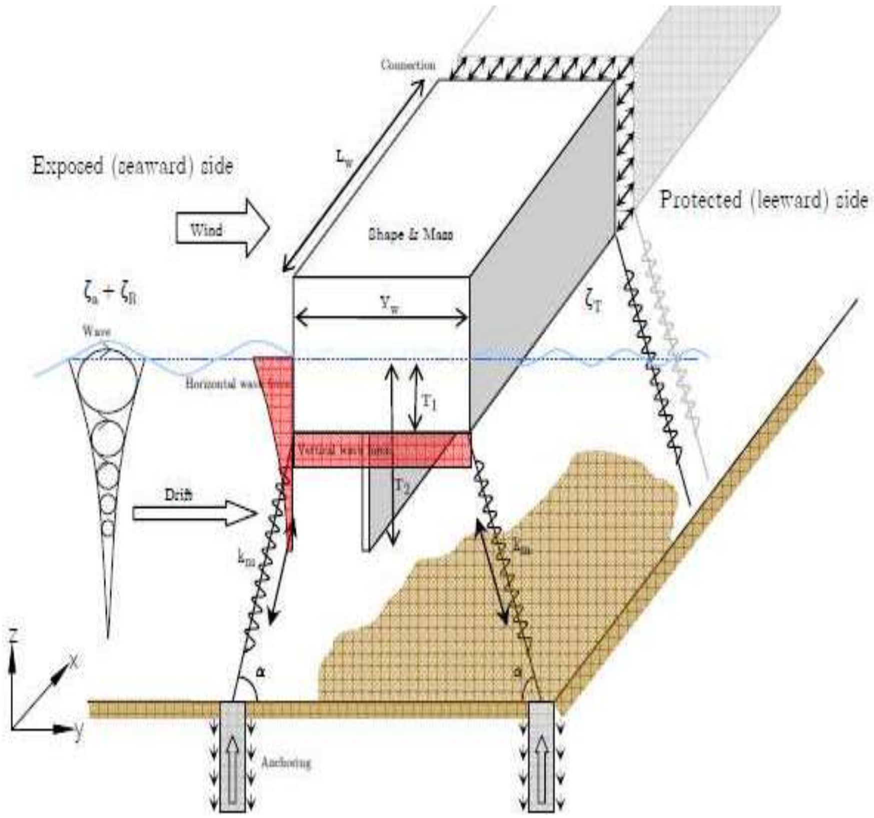


Figure 4.3 : Limit conditions of the floating breakwaters (Fousert, 2006).

The output in the proposed model of the study is the user motion comfort target levels. Wind-wave induced motions effects on the structure and the response of the structure in return and vulnerability of the structure affect the users most. Consequently, fuzzy logic linguistic variables such as ‘ best, good, average, bad and worst’ are used to describe these vulnerability levels. In Table 4.1, the model fuzzy logic linguistic variables of the model for determining the user motion comfort target levels are stated.

Table 4.1: Variables for user motion comfort target.

Fuzzy Logic Linguistic Model Variables	**User Motion Comfort Target Levels for Model Requirements Based on Expert Opinion**
(1) Worst	The vulnerability of the architectural building does not include life risk
(2) Bad	The vulnerability of the architectural building can be repaired
(3) Average	There is some vulnerability but the comfort levels permit long-term living
(4) Good	Comfort conditions appropriate for average level sleep
(5) Best	Comfort conditions resemble to land-based architectural structures

4.2 Wind Velocity to Superstructure Area Relation to Motion Comfort Target

Regional environmental conditions have strong effects especially upon the size of the floating structure, however these environmental limit conditions are generally considered at later stages in projects because of poor expertise and lack of internationally recognized standards. So, these environmental limit conditions should be properly understood and clarified at an early stage of the design process.

In the study, wind force parameter is considered in a correlation to the wind velocity effect on superstructure area and form. The correlation formed with expert opinion and the following formula are used in the design parameters of the wind force correlation with superstructure area and form linguistic variables.

Safir Simpssonn Hurricane scale is taken as an example in evaluating the environmental limit conditions about the wind and naming the determined degree levels with linguistic fuzzy logic. The scale was formulated in 1969 by Herbert Saffir. It serves to frame the level of structural damage to dwellings due to windstorms. Dr. Simpson added information about storm surge heights that accompany hurricanes in each category. Safir Simpson Hurricane scale is from 75 mph to 155 mph; however, the wind velocity degree levels, stated in Table 4.1.2, are determined to be in this study from 0 mph to 35 mph that are considered to be used in North Marmara Sea of Turkey.

Wind velocity correlation with superstructure area is the first parameter of the proposed process model. It is accepted as the first design criteria based on expert opinion.

The following formula is used to give you an idea about the proposed procedure in forming the correlation of wind velocity and superstructure area characteristics within user motion comfort targets.

$$P = [0,5 \text{ x } d \text{ x } cw \text{ x } a1 \text{ x } v^2] \text{ where}$$

a1 is projected area in sq meters of the portion of the floatation system and superstructure above the waterline,

d is air density (1.255 kg/m^3) a1is perpendicular side section area of structure (m^2),

v is wind velocity (m/sn) and

cw is co-efficient about the exterior form.

In other words, the variables of the wind force parameter are wind velocity, superstructure area and superstructure form.

In Table 4.2, wind velocity and the use of fuzzy variable are discussed in line with the adapted beaufort number levels and the reference scale of Safir-Simpson.

The wind velocity degrees are from 74 mph to 155 mph; however, it is 0-35 mph in the study. After the limit conditions for the wind velocity is determined, the wind pressure formula is used including superstructure area and the geometrical form co-efficient, later used in the application stage of the process.

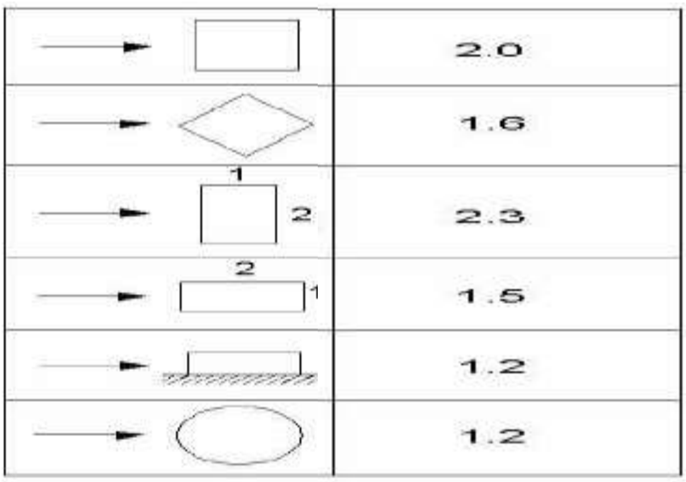
Table 4.2 : Wind velocity parameter levels.

Wind Velocity Model Fuzzy Logic Linguistic Variables	**Wind velocity scales**	**Wind velocity (mph)**
Best	0-1	0.00-7
Good	2-3	7-14
Average	4-5	14-21
Bad	6-7	21-28
Worst	8-9	28-35

In Table 4.2.1, an explanation about the use of linguistic variables in naming the wind velocity levels, is adapted from hurricane degree levels. In the study the correlation of wind induced motion effects on the whole-body structure response correlated with user motion comfort target levels are stated using linguistic variables based on expert views. Beafort number is a general correlation between wave height-wind speed.

In Table 4.3, the change of the coefficient with the change of the form is stated.

Table 4.3 : Cw values; drag co-efficient about the exterior form.



In Saffir-Simpson scale category seen in Table 4.4, 1 refers to ‘minimal ‘ linguistic variable, which shows 74-95 mph wind velocity but also ‘damage to unanchored mobile homes, shrubs and trees’, and 3 refers to ‘major’ linguistic variable, which shows ‘structural damage to houses, large trees blown down, flooding near coast’. Consequently, fuzzy variables are used in the study to address the correlation of wind velocity and superstructure area and then to form a rule-based system based on expert opinion as a decision support in deciding the size of the required floating superstrucure area and approximate geometrical form.

Table 4.4 : Saffir-Simpson scale linguistic degree levels.

Category	Winds	Damage
1	74-95 mph	Mimimal
2	96-110 mph	Moderate
3	111-130 mph	Major
4	131-155 mph	Extensive
5	➢ 155 mph	Catastrophic

In Table 4.5, the fuzzy logic degree levels of the study can be seen as ‘worst, bad, average, good and best’. These variables describe expert opinion about the wind force parameter correlated with the affected area and form.

Table 4.5 : Variables for wind force & superstructure area & form.

Correlation of Wind Force with Superstructure Area&Form Fuzzy Logic Linguistic Model Variables	Correlation of Wind Force with Superstructure Form/Area Model Requirements Based on Expert Opinion
Worst	1
Bad	2
Average	3
Good	4
Best	5

The form of the floating structure mostly depends on its function but also on environmental conditions in terms of wind. The wind also generates a surface current. These effects of the wind depend on its velocity, duration, direction, coastal topography and depth of the sea. However, the effect of wind loads on superstructure area and form is discussed based on expert opinion to form the rule-based decision support for determinig the geometry of the floating architectural structure.

4.3 Wave Height to Freeboard Correlation with Motion Comfort Target

Specific contributions of environmental loadings were mostly not taken into account in the past; however, nowadays the sufficient improvement of the environmental loads such as wave motions that have constant effect during transportation, installation and operation of the floating structure during its life cycle is accepted to have a substantial effect on the design process model practices.

Horizontal forces resulting from waves are in general several times greater than non-seismic horizontal loads on land-based structures and the effect of such loads depends upon how the structure is connected to the seafloor. In the study, a proper mooring is used. It is a mechanism that will allow maximum horizontal motions of a floating structure in the order of the wave amplitude.

It is accepted that wave height to freeboard height correlation is actually about the mooring system of the floating structure. However, the working mooring system in this study is determined based on expert opinion and the linguistic variables are given names according to their effect on the user motion comfort targets.

In Table 4.6, linguistic variables for wave height scales adapted and evaluated from Beaufort number levels are summarized.

Table 4.6 : Wave height parameter levels.

Wave Height Variables	Wave Height Scales	Wave height (m)
Best	0-1	0.00-1.2
Good	2-3	1.2-2.4
Average	4-5	2.4-3.6
Bad	6-7	3.6-4.8
Worst	8-9	4.8-6.0

Consequently, these linguistic variables are used in the study to describe the correlation of wave height and freeboard height with their effects on motion comfort target levels.

The height of the freeboard is considered to be an important design criteria, which is determined in the study with the support of rule-based fuzzy linguistic decision system considering expert opinion (Patil, 2010).

In Table 4.7, the model for fuzzy logic linguistic variables in relation to the correlation of wave height with freeboard height is stated. The table shows that a great deal of expertise is needed to determine the variables even for the problem of selecting the appropriate freebord height correlated to current wave height.

The current wave height should always be within the determined range given in Table 4.7. The aim of the designer will be adjusting the freeboard height to reach the desired motion comfort target levels.

Table 4.7 : Variables for wave height & freeboard height.

Fuzzy Logic Linguistic Model Variables	**Correlation of Wave Height with Freeboard Height Model Requirements Based on Expert View**
Worst	1
Bad	2
Average	3
Good	4
Best	5

4.4 Wave Length to Building Length Correlation with Motion Comfort Target

In a floating structure, the static vertical self weight and payloads are carried by buoyancy. If a floating structure has a proper mooring system, consisting, for instance, of the catenary chain mooring lines, the horizontal wave forces are balanced by inertia forces. Moreover, if the horizontal size of the structure is larger than the wave length, the resultant horizontal forces will be reduced due to the fact that wave forces on different structural parts will have different phases (direction and size). The forces in the mooring system will then be small relative to the total wave forces. Main purpose of the mooring system is then to prevent drift-off due to steady current and wind forces as well as possible steady and slow drift wave forces, which are more than order of magnitude, less than first order forces. (Watanabe, 2004)

Wave length; In physics, the wavelength of a sinusoidal wave is the spatial period of the wave—the distance over which the wave's shape repeats. Eugene (1987), states that in wavelength of a sine wave, λ, can be measured between any two points with the same phase, such as between crests, or troughs, or corresponding zero crossings as shown in Figure 4.4.

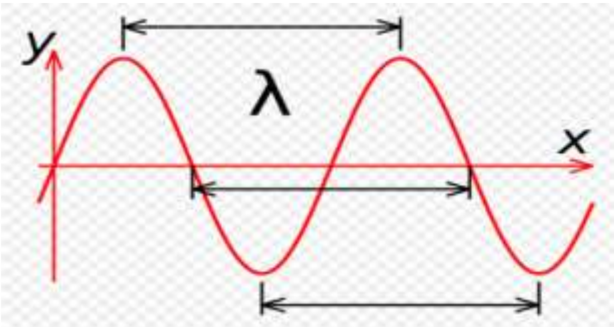


Figure 4.4 : Wave length.

In Table 4.8, 'Wa/L' is the third parameter of the study; Wa represents wave length, L represents the width of the floating base. 'The width of the floating base in the direction of the wave propagation is greater than one half of the wavelengths and preferably as wide as the indicent wave length; or else the floating base rides over the top of the wave without attenuating it'. In the study, the correlation of Wa/L is used in fuzzy linguistic parameters with expert opinion as a decision support for improved motion comfort target levels.

The three input parameters with their 13 linguistic variables make 75 rules. With the support of expert opinion, these general rule bases will be decreased down to 67 basic rule bases in the application phase of the study.

The rules can be used as a decision support in concept design phase for modeling of floating architecuture, where motion comfort target level is accepted as a primary problem for wind-wave induced motion effects on the floating architectural structure's behaviour.

Table 4.8 : Variables for wave length & floating base width length.

Correlation of Wave Length with Structure Width Length Fuzzy Logic Linguistic Model Variables	**Correlation of Wave Length with Structure Width Length Model Requirements based on Expert Opinion**
good	Wavelength / Structure Width Length < 0,5 or Wavelength / Structure Width Length >2
average	2 > Wavelength / Structure Width Length > 0,5 & Wavelength / Structure Width Length =1
bad	Wavelength / Structure Width Length = 1

4.5 Limit Conditions Findings

This section follows the explorations of three distinct parameters which throughout the design of the surface geometry of the floating architectural structure have the greatest importance when dealing with motion-induced loads affecting user motion comfort target levels.

The questions that are discussed in the limit conditions section of this study are:

- 'What happens when an architectural structure floats?'
- 'What if an architectural structure moved on water and what else can its geometry say about its response to dynamic loads such as wind-wave induced motions?'
- 'How certain changes in geometric dimensions provide a design with efficient performance and motion user comfort target levels?'
- 'What is the difference between a land-based architectural structure's design process and a floating architectural structure' design process?

This section examines a means of evaluating and developing the design process of floating architectural designs with linguistic variables translating the rule-bases with expert opinion. This is a way to use non-linear design strategies in architectural design process. Using the power of natural condition change for process design and computation of incredibly complex structural behaviour of floating architectural structures under the various effects of wind and wave induced motions, adaptation within the environment considering natural condition change as a part of the modeling system is achieved.

As seen in Figure 4.5, wind force - superstructure area and form, wave length - structure width length, wave height - freeboard height correlations are discussed in limit conditions section and a design process model is formed with these three input parameters.

This section aims the evaluation of three proto-architectural requirements as a base system with the capacity to assist self structure configuration of floating architectural design.

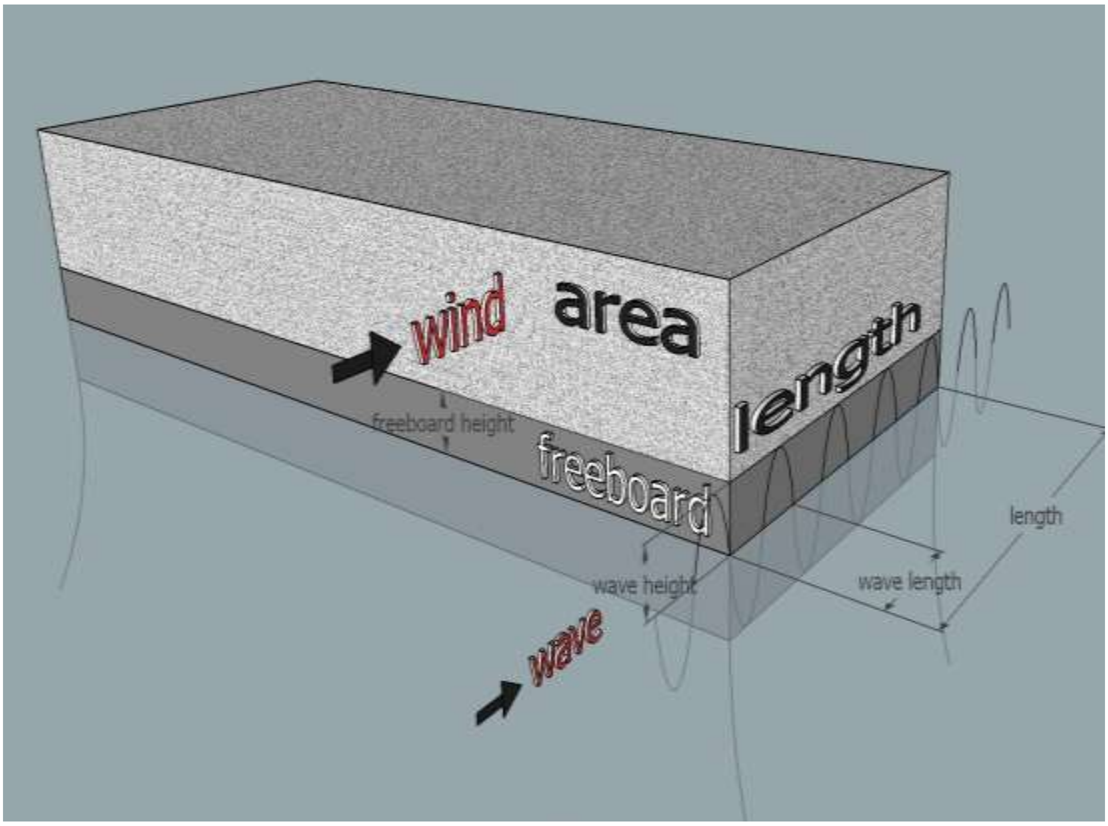


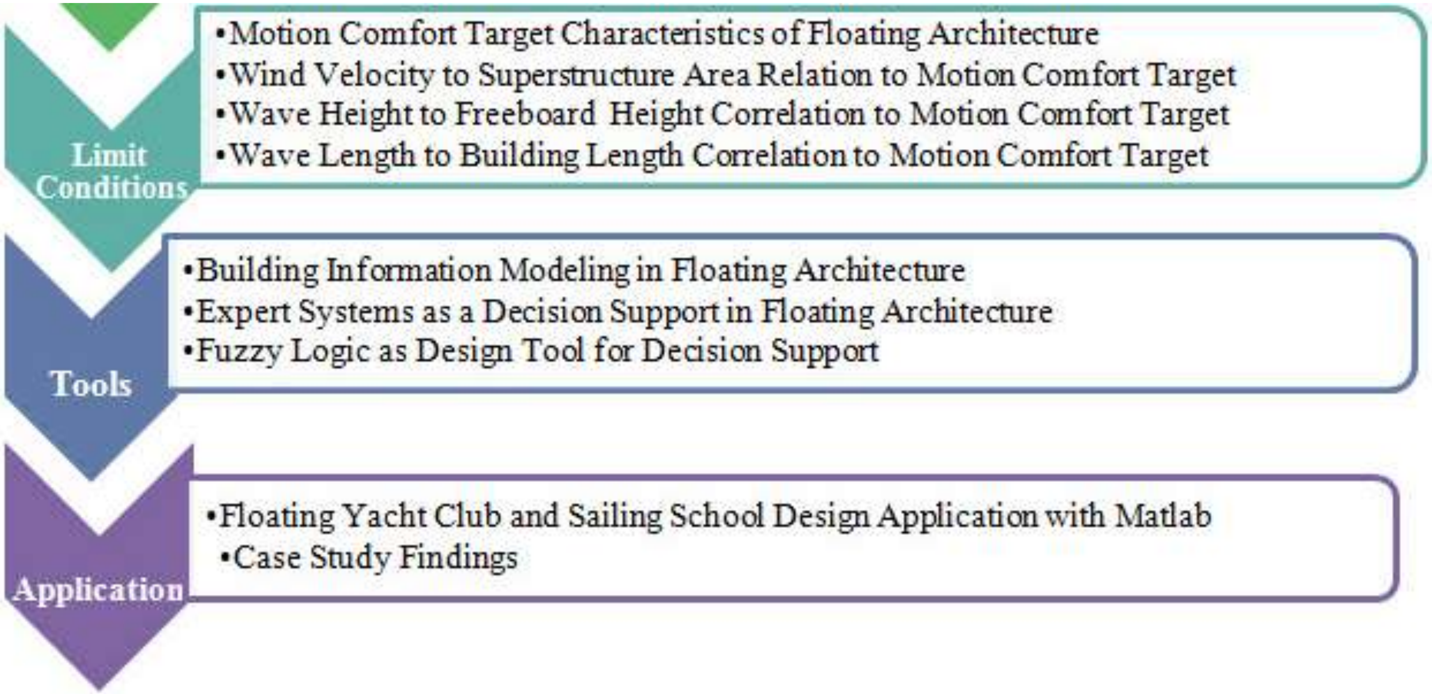
Figure 4.5: System input parameters.

The section consequently aims to form correlations by discussing the physics of natural processes not only as a design generator, but also as a decision support tool for redesigning the complex correlated forms by fuzzy logic linguistic variables. More specifically, the main focus of thesis is evaluation of a non-linear design process model. By analyzing the correlation between motion-induced loads and floating structure's response and determining the levels of certain environmental conditions and sea-state levels, the performative qualities of user motion comfort levels can be controlled. These features and qualities are explored through fuzzy logic linguistic variables and experts' considerations at each determined level. As a result, three detached variables combined with expert opinion are converted into a new fuzzy logic based language providing designers a tool for new design process modeling of floating structures.

This section points out the importance of limit conditions in the design process of floating structures. The limit conditions are discussed and evaluated focusing on different approaches that are explained in approaches section. The stated approaches give the designers the ability to design with the determined limit conditions.

In limit conditions phase, the probability of determining the linguistic degree levels of dominant motion effects on the form of the structure is understood and in the following section, the tools used in the design process model are discussed. After the wind-wave induced motions and their correlations with the geometry of the floating structure are determined in the limit conditions phase, the way to use these parameters in the design process of floating strctures are explained in the tools section. Following the limit conditions phase as seen in Table 4.9, the connections between the tools and the determined design parameters are discussed.

Table 4.9 : Process schema of the study after limit conditons phase.



5. TOOLS FOR DESIGN MODELING PROCESS

The complexity of the task to develop appropriate modeling tools for the design process of floating architecture is a challenge for designers. The degree of flexibility and the adaptivity increase in the design process of floating architectural structures turn out to be the reason for greater dynamic responses to wave and wind induced loading.

Floating architectural design process modeling tool must be optimized to achieve the required motion user-comfort target levels. Unlike land-based installations, in the floating architectural process design, a large focus must be placed on intelligent tools such as linguistic fuzzy logic decision support to ensure the required performance levels. More optimistically, floating architectural design process modeling tool may provide a new design paradigm that may offer unique opportunities to reduce vibrations causing motion sickness for the users.

In the tools section of the thesis, tools, which are determined in the research phase and approach phase of the study, are used. Consequently, these tools are used in modeling the human-vehicle interface for predicting the correlation between the geometry of floating structure and wind-wave induced loads and their dynamic behavior causing floating structure's response.

In Table 5.1., tools used in the design process modeling of floating structures of this study are listed as building information systems, fuzzy logic as a tool for decision making and expert systems as decision support.

Studies of Leeuwen (2004) stating recent advances in design and decisin support systems are discussed and the way to use these tools in the modeling of floating architectural design process is explained and importance to evaluate the design parameters is stated.

Table 5.1 : Tools used in thesis.

5.1. Building Information Modeling in Floating Architecture

In this decade, architectural designs turned out to be not only drawings but also, digital and linguistic information.The importance of new design studies increasingly supports the evaluation process of the future of architecture, such studies; Knauer (2008), Lidwell (2010), Lawson (2006), Fajardo (2009), Kolarevic (2008), Cross (1984) include information about hi-tec architecture, principles of design process and methodology. Consequently understood from these studies that early good decisions become more important for cost, quality and user comfort levels over all design levels. As seen in Figure 5.1, it is undeniable that the impact of decision time changes with available information (Fisher, 1993).

In the study, where design is developed in collaboration with other disciplines (naval architecture, mathematics, architecture and environmental sciences), building information systems have a crucial role in the design process evaluation. Using rule based decision support system for modeling the design of floating architecture, gathering multidisciplinary information to have the confidence to play with rules without changing them and deciding the right time to involve the designers actively and to change the course of process can be achieved with the support of building information systems.

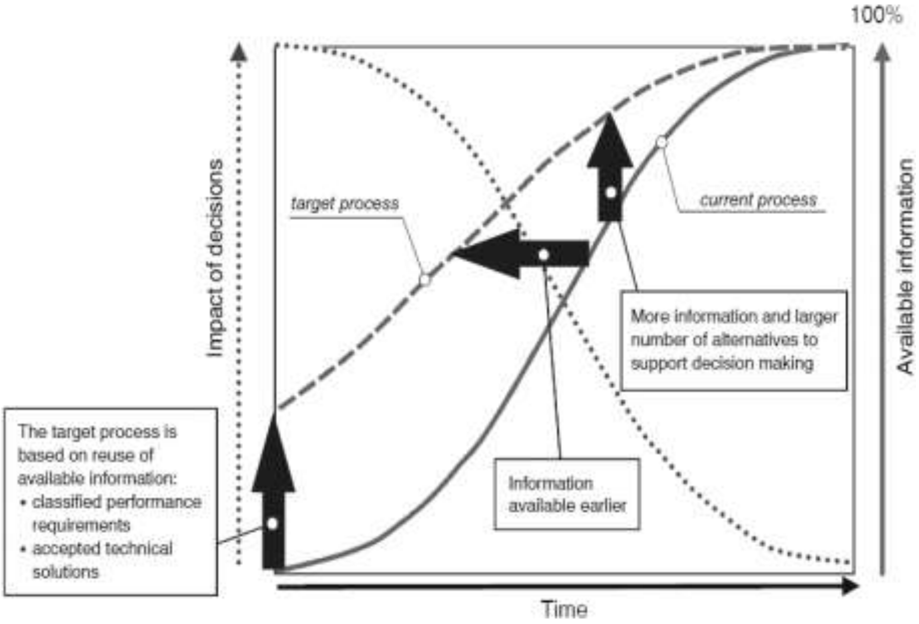


Figure 5.1 : Decision making versus available information (Fisher, 1993).

The outcome of this informative and responsive process can be a group of simple rules improving user motion comfort target complexity. By using simple rules to develop complex results and using linguistic approach, proposed floating architectural design process model is evaluated.

In Figure 5.2, the schema is used to show the steps to decide the tools used for floating architectural design from the physical models, numerical models and trial and error models. The proposed model is fuzzy logic linguistic variables.

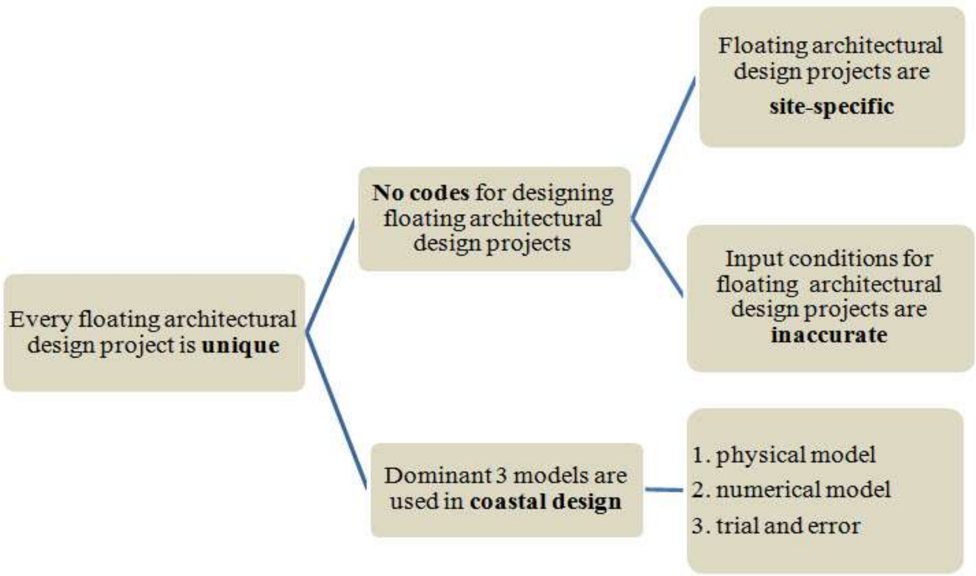


Figure 5.2 : The model decision schema.

The floating architecture design has a high complex process schema. If the entry of many command words and parameter values to a computer-aided design system can generate a great deal of construction content, the project is of high complexity. In this study, the complexity is minimized by standardizing the spatial relationship between environmental and performance-based design parameters causing complexity. This standardization can be done with the support of building information modeling, where the information about the structure is used to form the linguistic rule-based decision support system. Figure 5. 3 shows the dominant issues for building information modeling, which are discussed in the thesis under the very variable effects of environment and performance design focusing on user comfort.

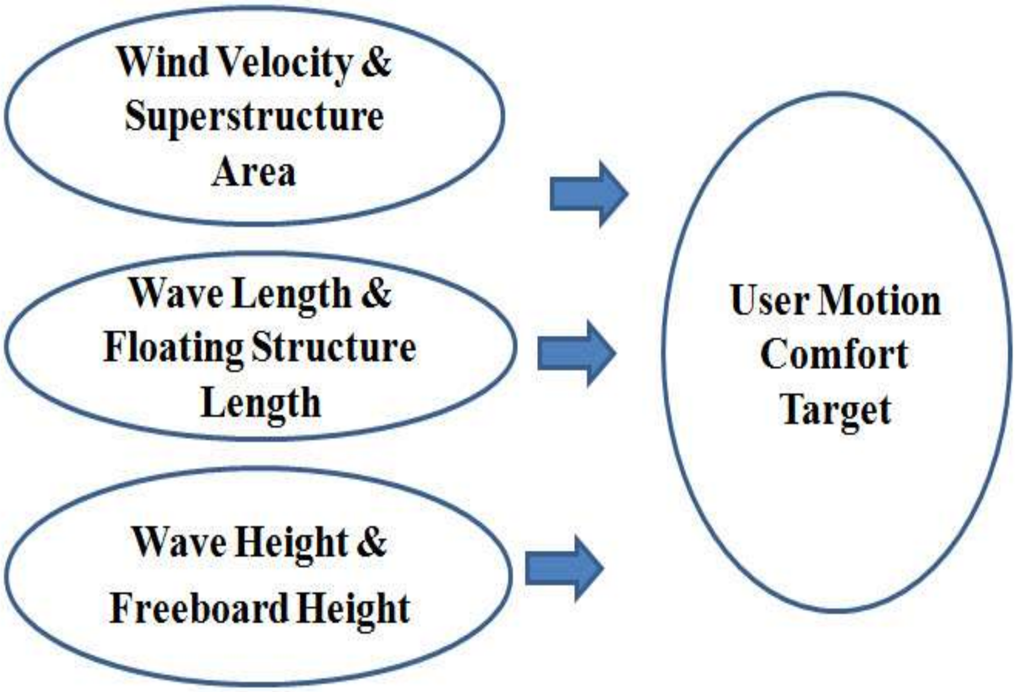


Figure 5.3 : Information schema of thesis.

The floating architectural structures in the thesis are accepted as a metaphor and are discussed as a case study of a new kind of building in the application section of the study. By preferring to design with rules, algorithms, and consequently, running the process, designing a new kind of building can be achieved.

The floating building is under the effect of environmental condition change, so these buildings can be evaluated as they operate on simple rules and acts according to environment.

In Figure 5. 4, the objectives and the focus objectives of the study which are the main fields of the building information systems can be seen. In the study, both environmental and structural objectives are discussed. From among environmental objectives such as temperature, lighting and humidity, vibration has the dominant effect on user health which is taken as the catalyst problem parameter for the proposed design model. Structural parameters are correlated with vibration parameter. Lateral and consistent live load effect of wave and wind are discussed as the second prior criteria of the proposed design model.

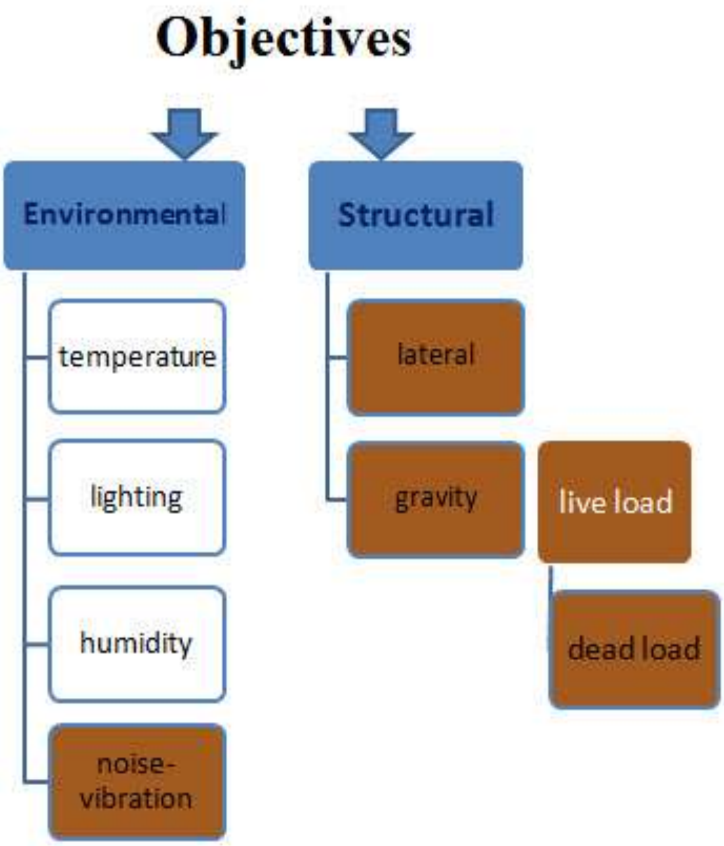


Figure 5. 4 : Building information data objectives of thesis (Kalay, 2004).

The proposed model of the thesis implies intelligence, where it is an awareness that combines the building relations from complex to less complex effects. Only by running the system the result of the the simple rules can be seen. However, floating architectural structures are accepted in the thesis as complex adaptive systems, which are adaptive to their environmental changes. By involving the changing circumstantial conditions of weather and other environmental data in the running process of floating architectural structure itself, looking at the world of design from another perspective can be achieved.

Floating architecture is also a metaphore. If the motion comfort target levels can be inserted in the very movements of floating structure throughout the running process of architectural design process itself, static foundations of architectural design process of floating structures can be changed.

The floating architectural buildings respond to changes caused by the environment due to their nature, and show changes by themselves according to a set of simple rules generating a copmplexity of possible configurations.

In this thesis, scalable physical system is formed with the support of linguistic variables that are obtained from using building information management as a tool to evaluate and generate the information of the design process of the floating architectural structures.

5.2. Expert Knowledge as Decision Support in Floating Architectural Design

In the study, expert systems are used as a design tool support and their correlleration and collaboration with the new product design of floating archirectural design process model are discussed. Consequently, the question; ‘How do humans think and decide?’ should be understood. In connection with the question, the brain analyzes through some phases as a series of reasoning processes using specialized and common knowledge it has accumulated. Some of this knowledge is instinctive and some is gained through education and some is gained by trial and error. The final outcome of this reasoning is the answer (Bross, 1966). In Figure 5.5a human thought process and Figure 5.5b artificial intelligence schema and their differences are summarized.

Artificial intelligence uses knowledge from data structures and from the rules which are determined with the experts of that specialized field (Ichida, 1996). In human thought process, the gathered knowledge can be specialized or common or it can be an acquired knowledge that is gained by education. However the type of knowledge used in the proposed model is rule based which is evaluated by the experts, as stated in Figure 5.5b.

‘People must have latest electronic gadget, but must cling tenaciously to ideas and methods of thinking that were absolutely three hundred years ago’ (Bross, 1966).

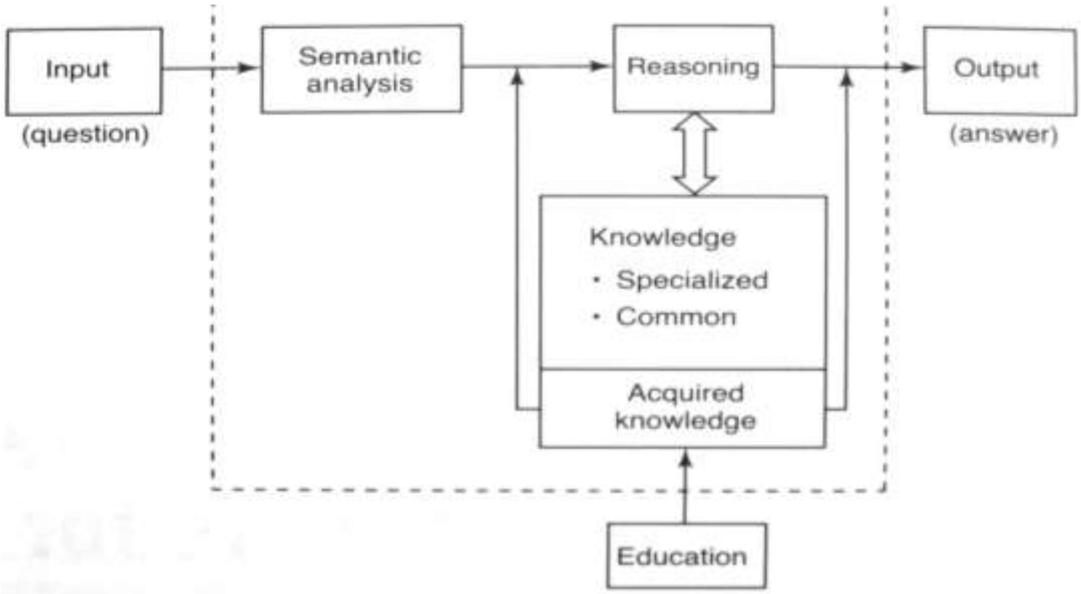


Figure 5.5.a : Human thought process (Ichida, 1996).

Artificial intelligence system is mimicking human thinking, using a knowledge base into which information has been entered and stored to understand the meaning of question and produce an answer via an inference engine. In the proposed design process model of floating architectural structures, rule-bases are evaluated with expert opinion. This is accepted as a sub-artificial intelligent system, where knowledge input is rule-based to get a required output as stated in the Figure 5.5b.

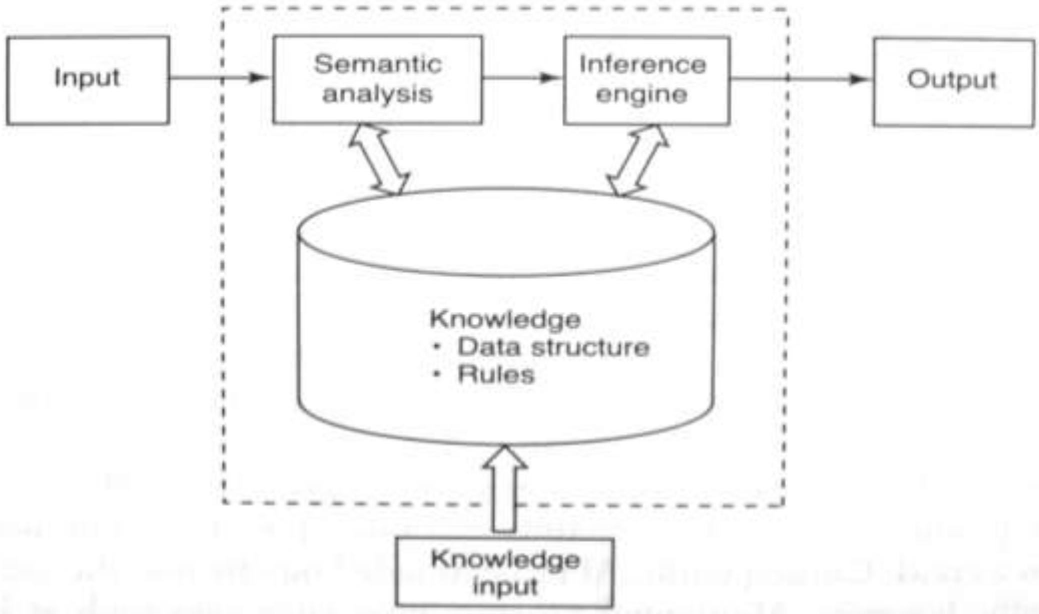


Figure 5.5b : Artificial intelligence process (Ichida, 1996).

Recently expert systems, natural language software, computer-aided systems and image recognition systems have been particularly successful in using artificial intelligence as an artificial thought mechanism. In Figure 5.6, the types of expert systems such as analytical, design and mixed type and their sub-properties are summarized. The proposed model of the thesis is a design type expert system.

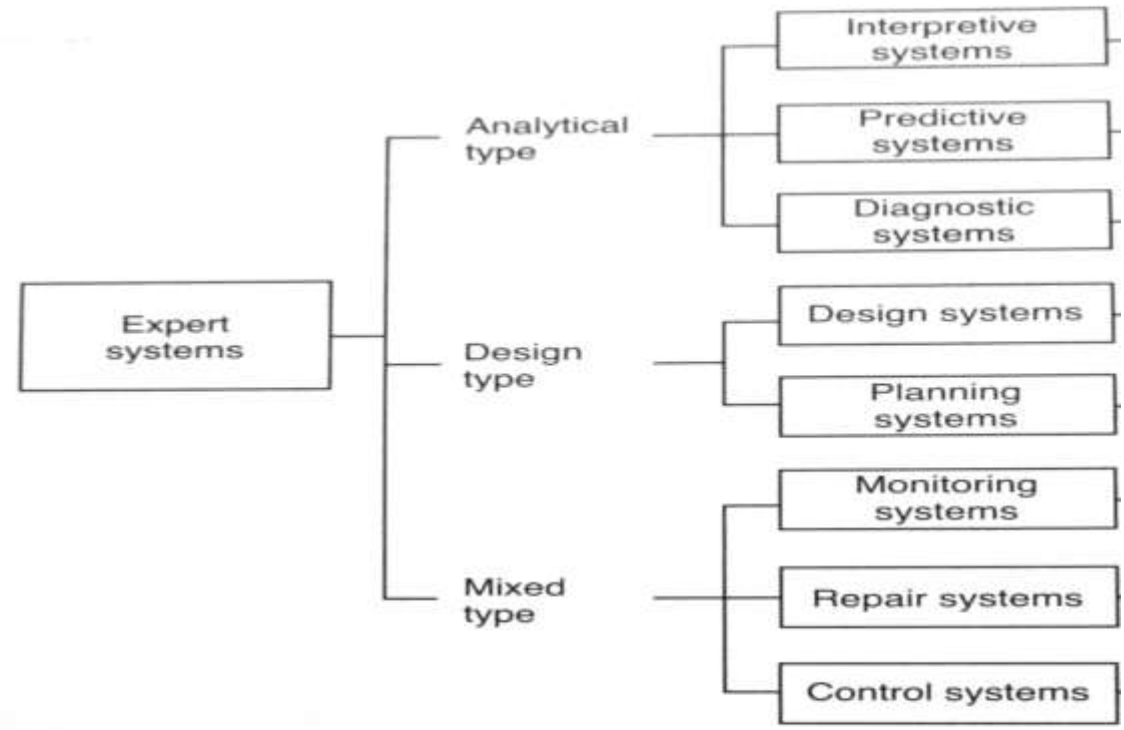


Figure 5.6 : The types of expert systems (Ichida, 1996).

The expert opinion and experience play a significant role in any preliminary assessment of an event through linguistic statements, principles and rule-bases, which do not require mathematical formulations. In fact, either for the preliminary assessment of any floating building against potential vibration or motion vulnerability, the features of the concerned buildings are checked against a set of empirical rules or an expert is invited for the linguistic appreciation of the overall situation. The expert bases the conclusion onto a set of previously experienced rules and principles. In Table 5. 2, artificial features used in the study are summarized. The special qualities of the proposed model of the thesis can be examined and the difference of the proposed system from the conventional systems can be identified. The main characteristic of the conventional systems are their great efficiency in high-speed data processing. However, this study uses artificial intelligence systems, which can process both the knowledge and the data in the proposed floating design model.

Uncertain nature of water–related design knowledge is discussed to provide a tool to the designers for creating the design process model of floating structures. It is accepted as a sub-artificial intelligence system using expert opinion knowledge processing method, where the target environment is ill-structured and algoritm is indecisive, by using linguistic variables of fuzyy logic in Matlab as knowledge and inference tool for symbolic processing.

Table 5.2: Artificial features (Ichida, 1996).

Artificial Features	**conventional system (high-speed data processing)**	**artificial intellegence systems (knowledge& data processing)**
user-machine interface	users work to suit the systems	systems work to suit the users
target environment	well-structured	ill-structured
algorithms	decisive	in-decisive
programs	data & procedures	knowledge & inferences
technologies	data processing manipulation & numerical calculation	symbolic processing pattern matching & searching
development approach	detailed system design	trial & error

Different researchers published wave-wind induced vibration studies and they become commonly used and internationally recognized criterion in very different scales of floating constructions. Within the consideration of the nature of floating architectural structure's behavior having multi-criteria, it is understood that the complexity and uncertainty urge the decision makers to reach a reasonable judgement. ‘Each one of these scales can be expressed in terms of fuzzy words in proper sentences (statements) such as ‘bad’, ‘ average’ and ‘good’’ Sen, (2010). The expert systems primarily accept that they can use specialized knowledge from a particular field whereas in this study, it is knowledge of floating architectural design systems where the expert systems are accepted as a tool that can handle very complex and specialized problems and solve them as much as the real expert can. Uncertainty stems mainly from sources such as the lack of incomplete data. The expert systems convert this incomplete data and uncertain knowledge into three major fields, using natural languages, linguistic approach and machine translations. In Figure 5.7, the expert system process is stated.

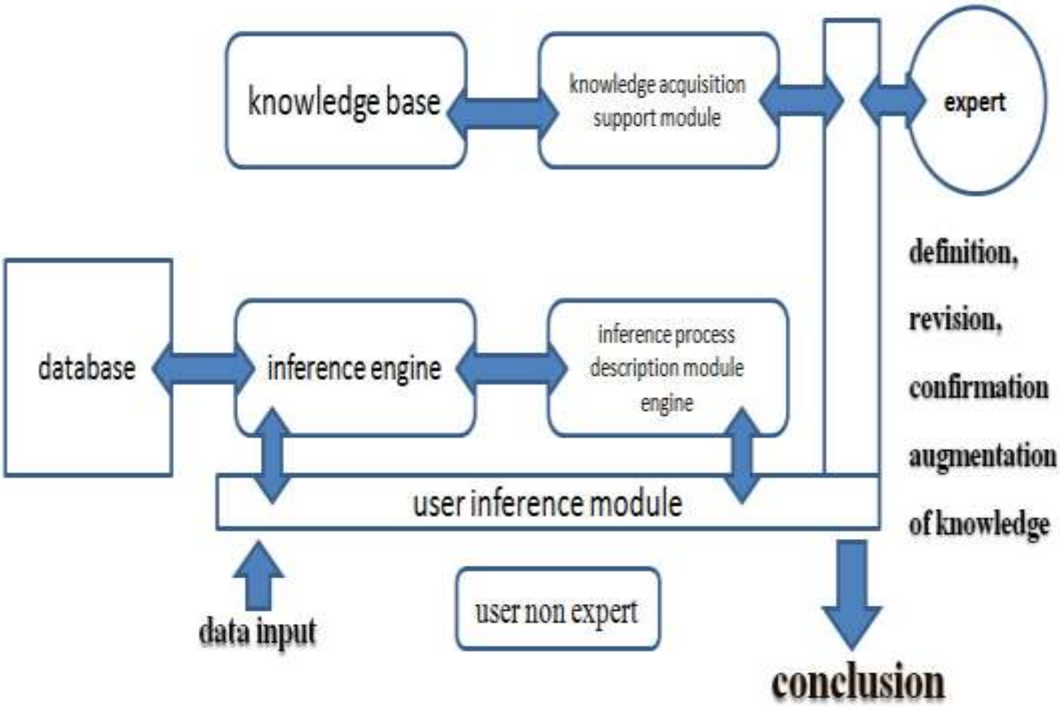


Figure 5.7 : Expert System Structure (Ichida, 1996).

The process of selecting one action from a number of alternative courses of action is referred to as decision. In the study, by discussing expert systems as a decision support in floating architectural design, it is accepted that it is necessary in a real complex situation to consult a professional decision maker or to take his approval for a completed action. The process of decision will select a single course of action from among alternative actions, which will actually be carried out. The decision process in the study does not include statistical decision because statistical decision translates the existing ideas into statistical terms, adds some ideas of its own and then assembles all these concepts into an integrated mechanism for decision-making. However, this study tries to translate the language of ocean and coastal engineering correlated with architecture, converting it into a symbolic one and into daily English with fuzzy logic linguistic variables. The process model is a complex machine, obtaining information from the real world of environmental limit conditions change, and out of it comes a recommendation for action in the real world. Consequently, the real world problem of floating architectural design process-vibration problem/motion user comfort target level - is translated into a symbolic language with fuzzy logic linguistic variables. The problem is solved with the expert opinion in symbolic form and the final answer is translated back into the real world decisions.

Using fuzzy logic linguistic variables as symbolic language is the integral part of the study. The use of symbolic language enables avoiding disturbed thinking and verbal confusion. By this method, the aim is to construct a decision maker for solving the problem of user motion comfort target level change in floating architectural design.

In the study, intensive focus is on explaining how a man-made decision maker works and the principles on which it operates. The process schema of the study forms the method that has great adaptation in new environments more than those built-in and unchangeable responses. Consequently, flexibility is considered a more important criterion than non-transmitted data. The new tool for transmitting behavior patterns are accepted as the language or linguistic variables. However, the transmission is in the pooling of experience that is obtained in a specialized field.

First, a model or picture of the real world phenomena of water- related problem of floating architecture is stated in limit condition section of the study. The model is discussed by the results of directed action taken in accordance with the model. However, a part of the model includes code of excuses to limit the conditions, within which it works. The system is rule-based and the expert opinion controls the rules from one set of statements (axioms) to another set of statements (theorems) in consistent manner. However, the theorem of the model is accepted to be true if it has a perfect description of the state of affairs of the floating architectural design process. So, a procedure for going from observations to statements is used in the study to solve the problem. The problem is described through making assumptions of the real world phenomena of floating structures.

5.3. Fuzzy Logic as Design Tool for Decision Support

Hydrological processes depend on factors that change: spatio-temporally in an imprecise vague and uncertain manner. The characteristic properties of data related to natural events/water-related phenomena are summurized in Table 5.3. These data are referred to as fuzzy information. The focus in the study is to find a way to process such fuzzy data.

Table 5.3: Data related to natural events / water related phenomena.

vagueness	imprecision	incompleteness	missing data

The way to process fuzzy data of water related / natural events is to encode human-expert knowledge under natural constraints in a simple manner without any need for training data, mathematical formulations and probability distributions.

The real world problem of floating architecture is complex and mathematical functions are difficult to apply. So, the interpretation of linguistic qualitative data is better achieved with fuzzy logic. In Figure 5.8, how data in the thesis is transformed to the proposed process model can be seen.

Figure 5. 8 : Transformation of the data in the thesis.

If the natural water-related phenomena and processes involved in floating architectural design process cannot be understood, uncertainties arise. Consequently, the model in the study is based on conceptualization of the water related phenomena. By developing an understanding about the relationship between natural variability and uncertainty seen in the natural processes in the limit conditions phase with determined approaches, the new model is proposed and the theory is presented in terms of a model, which is comperatively easy to understand, because it is structured in a similar manner to the existing design practices. Supporting the objective of the model, the application of the model aims to design the geometry and dimension of floating structure.

Figure 5.9, the reason pattern for using fuzzy logic linguistic variables rather than numeric method in the study is schematized.

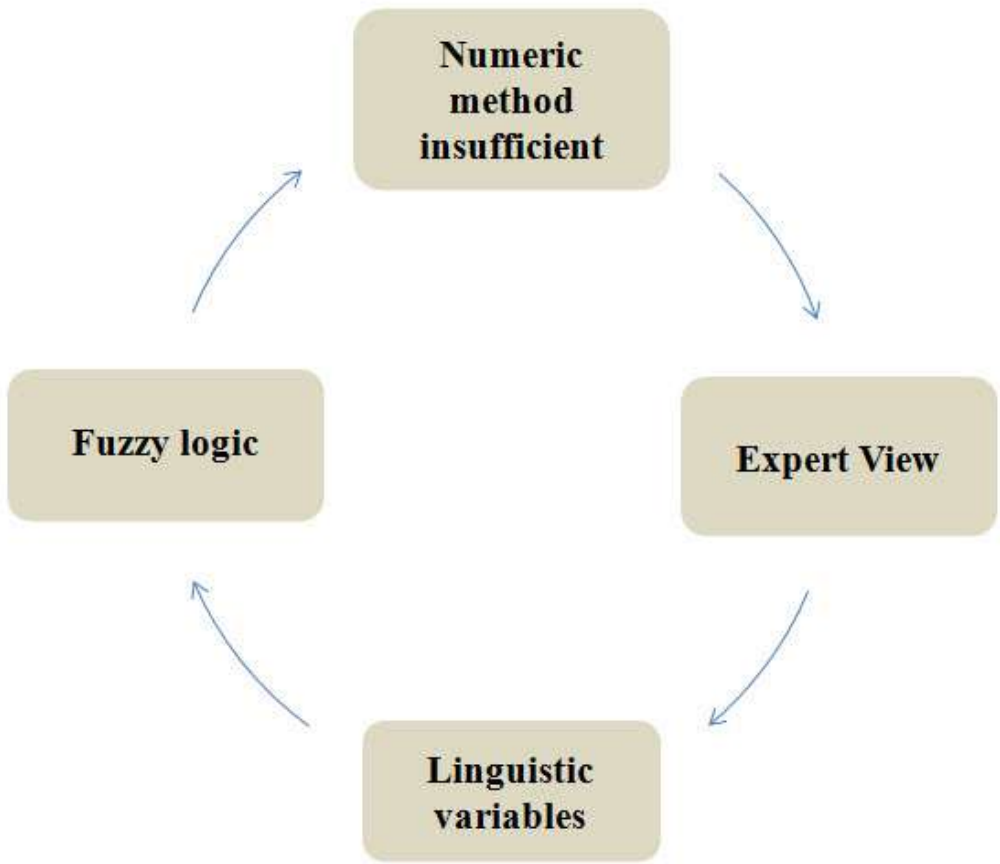


Figure 5. 9 : Reason for using logic rather than numeric method in the study.

The classical white and black data can not be found in hydrological data, which are uncertain and gray. In the research phase of the study that benefits from the literature review and applied researches, it is understood that readily available equations and algorithms may not be a sufficient solution for this type of uncertain and gray data. However, linguistic knowledge, experience and expert opinion assist in establishing the preliminary skeleton of the solution, which may later be supported by numerical data. If the background of the working mechanism related to natural water phenomenon is not appreciated qualitatively through verbal information, only numerical data are pumped into mathematical models.

Studies on modeling complex systems have become a focus area in recent years. Mathematical relationships are used for increasing the number of input parameters under different environmental conditions. However, when system input parameters or the level of complexity of relationships between input- output pairs are increased, problems arise. Non-linear system modeling can also be satisfactorily achieved by intelligent system modeling studies.

In this study, solutions are suggested for non-linear problems with fuzzy logic modeling and a new modeling approach is proposed based on linguistic rules. The proposed modeling approach is based on determining the design parameters of the complex system and visualizing the relationship between different inputs and outputs variables. As the final step with fuzzy logic techniques, forming the logical detail of the system mechanism of hydrological sciences phenomena without mathematical formulation is as stated in Figure 5.10. where in Figure 5.11, the questions that discuss the way of dealing with uncertain information and the way to use fuzzy logic with linguistic are listed.

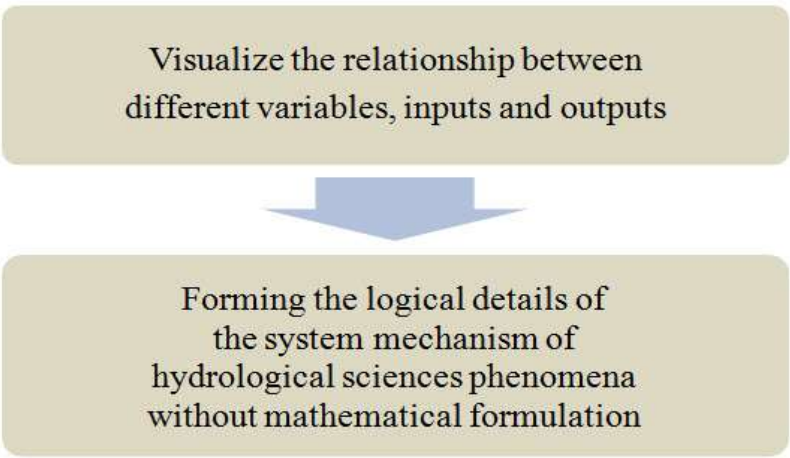


Figure 5. 10 : Conceptualization of the data of hydrological sciences phenomena.

Complexity can be divided into two parts, quantitative aspect and qualitative aspect. The quantitative is regarded as a large scale of an entity or a large number of elements within this entity. The qualitative aspect is accepted by some uncertainty in the data or knowledge about an entity. Qualitative aspect is used in this thesis for the modeling of the decision support of floating architectural design process.

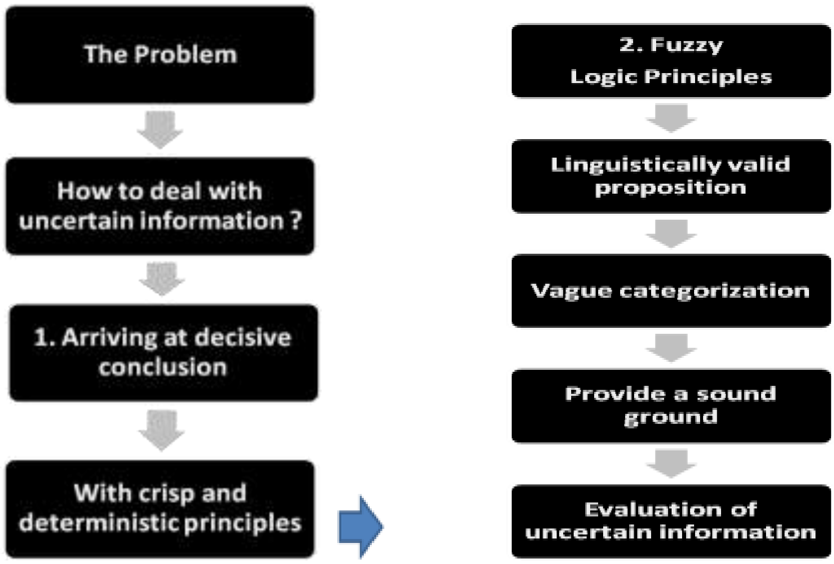


Figure 5. 11 : How to deal with uncertain information in floating structures.

The focus of the study is fuzzy logic, which is accepted to be a way of dealing qualitative complexity. In modeling design of floating architecture, the uncertainty in the data or knowledge about the entity parameter is transformed by the rule bases of the fuzzy systems. In Table 5.12, fuzzy logic linguistic variable use and degree levels are described in an example, where the height of a man is determined.

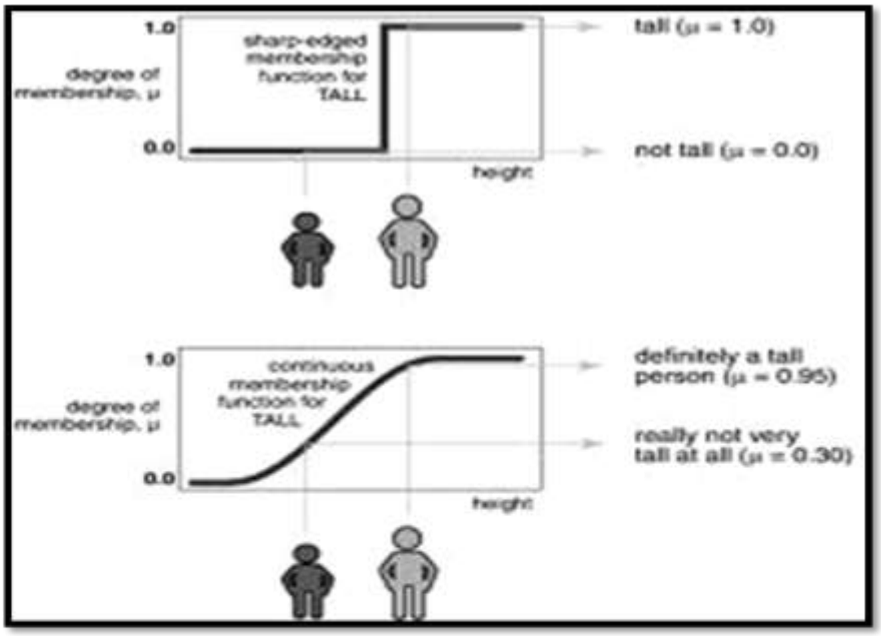


Figure 5. 12 : Crisp and fuzzy MF (Matlab Fuzzy Logic Toolbox Tutorial).

Fuzzy logic is accepted as a matematical system widely used in artificial intellegence issues and automated control of machines. It uses the way that human solves problems as well as learning skills of human beings and thought mechanism. From fuzzification of the knowledge to defuzzification of the output, evaluated decision unit uses both the data base and the rule-base. However, in the study, the fuzzy logic usage is limited. It is used as a tool to form a rule-base interface for decision support for the design process modeling of floating structures. As stated in Figure 5.13. fuzzy inference system, the study determines the rules by experts.

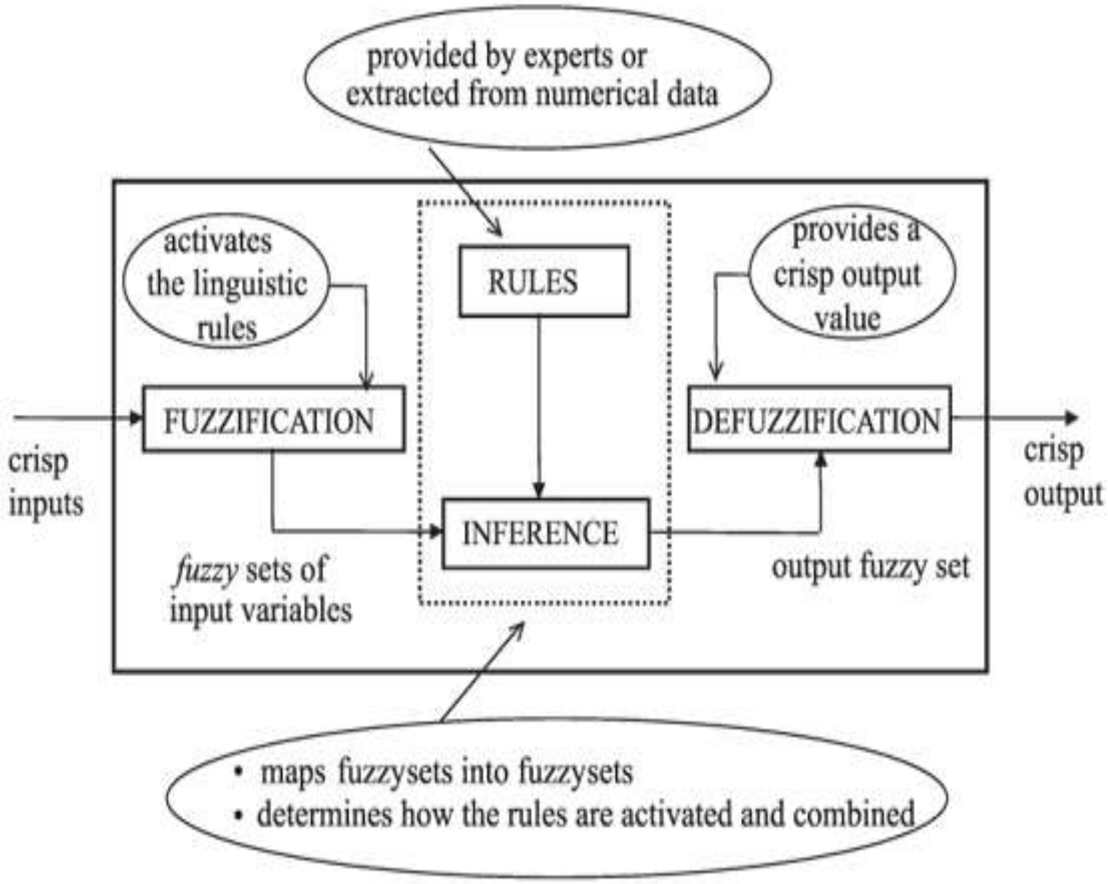


Figure 5.13 : Fuzzy inference system (Matlab Fuzzy Logic Toolbox Tutorial).

Redefining how we think about logic, Zadeh (1965), states that 'people do not need precise numerical input to make decisions' and introduces 'a class with unsharp boundaries'.'Concept of linguistic variable and its application to approximate reasoning' Numerical solutions are too sharp for the complex world problems. The probabilities calculate whether a thing would be or not, fuzzy logic calculates the degree of a thing being.

In Figure 5.14, the usage of fuzzy logic linguistic variables degree is summarized.

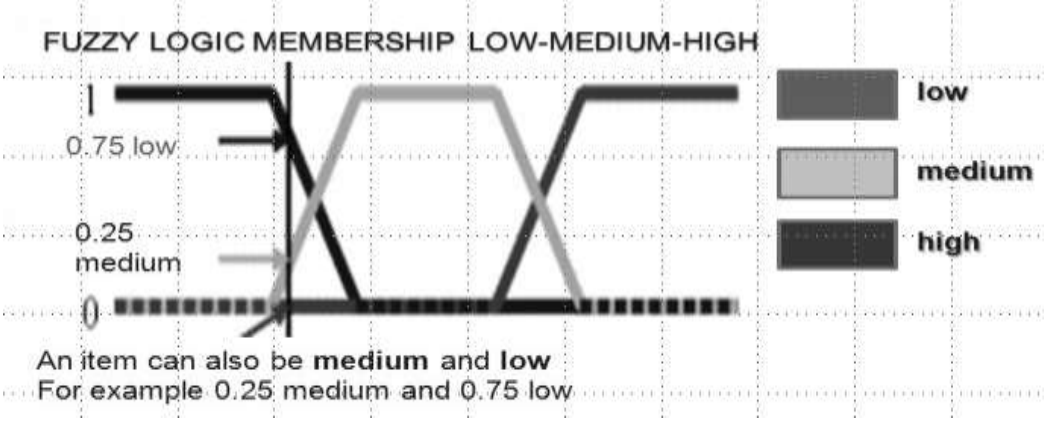


Figure 5. 14 : Fuzzy logic degree of being.

A fuzzy network can be accepted as similar to a neural network which uses computational intelligence based networks with nodes and connections. However, the nodes in a neural network are neurons, whereas the nodes in a fuzzy network are rule bases. Fuzzy systems handles different attributes of complexity with rule bases. Lane (2009) states in his studies about complexity that it should be handled carefully as a support for the innovation of social change with a new perspective. In Figure 5.15, fuzzy logic variables and the solution circle and the goal circle and their degree of membership are summarized.

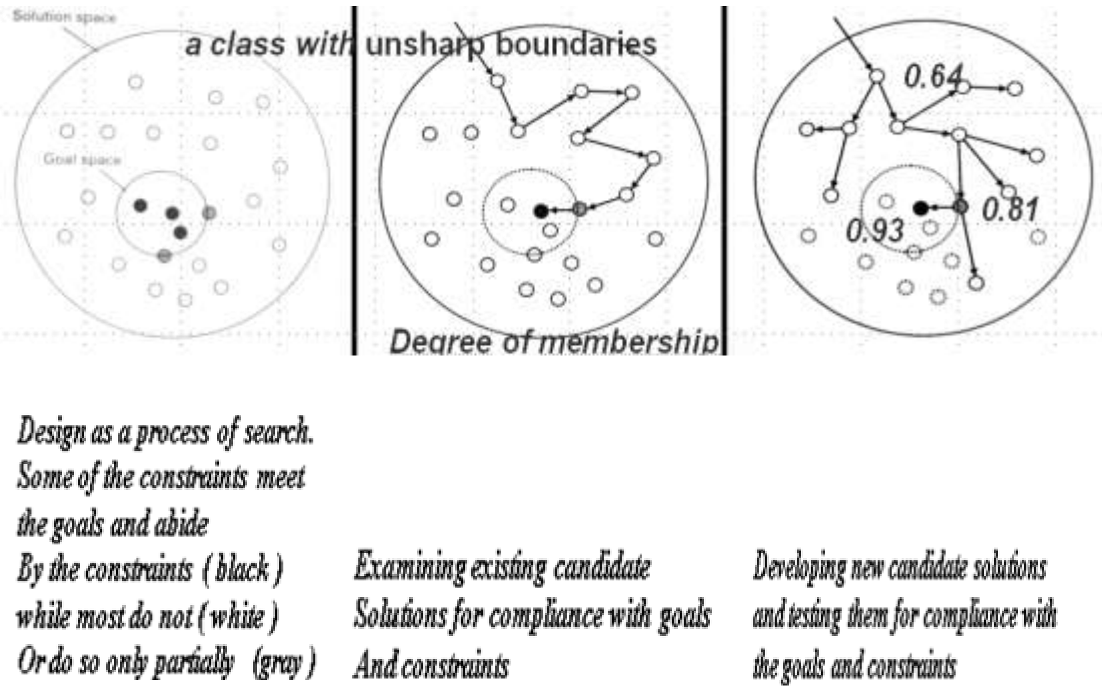


Figure 5. 15 : Fuzzy logic degree of membership adapted from (Kalay,2004).

The model of the thesis discusses three input parameters and an output with expert opinion and there is the fuzzy logic rule base between them. Rule bases are linguistic variables, which are accepted as the communication step of a design process combining and providing the required cooperation between analysis, synthesis and evaluation steps. As stated in Figure 5.16, analyis, synthesis and evaluation are linked to communication and linguistic variables are widely used in the design process and accepted as the major components of architectural design process.

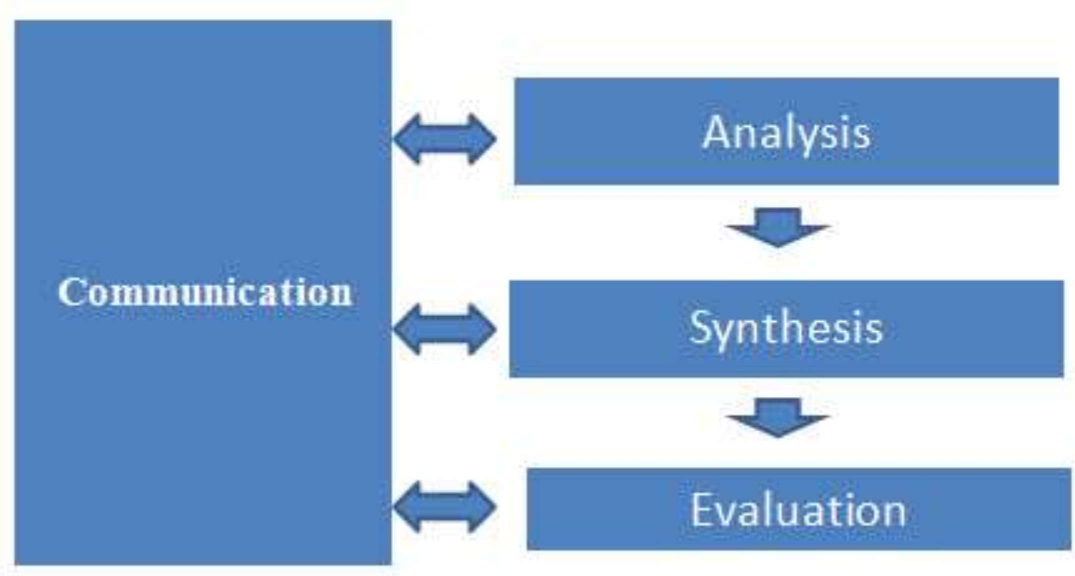


Figure 5.16 : Major components of architectural design process (Jones, 1980).

The study tries to find an answer for the question 'Why linguistic fuzzy logic?'

The answer is; fuzzy networks for complex systems and floating structures can provide designers a rule based approach and can give an oppurtunity to designers to generate the ability of computing with words and to develope cognitive maps.

The problems of floating structures are not amenable to mathematical analysis because of the nonlinear character of the governing equations of motion, lack of information on wave breaking, turbulance or bottom friction Field observations and measurements are expansive. Field observations need too many variables, which can easily get out of the control of the observer. Laboratory measurements and observations are accepted as physical models, which are not appropriate because of their drawbacks of scale and laboratory effects. The mathematical calculations are inadequate because of wave refraction, shoaling and diffraction of the dominant parameters. (Hughes, 1993).

In Table 5.4, the models used for water-related structures' calculation and their disadvantageous characteristics are summarized.

Table 5.4 : Models for water-related structures (Hughes, 1993).

Field observations and measurements	• Expensive, too many variables of nature, no control
Laboratory measurements and observations	• Physical models, drawbacks: scale and laboratory effects
Mathematical calculations	• Wave refraction, shoaling, diffraction are dominant parameters

‘It has been more than a decade since the advent of new technology as a modeling tool on architect’s and designer’s desktops. More importantly, it has been more than twice as long since the advent of digital technology in workshops, fabrication shops and factories. When faced with the new and exotic tools for design, it was assumed that the fresh new digital imagination of designers exceeded the available technology. In fact it was and it is still reverse. The potential of digital construction is for the most part untapped by architects and designers. It is only recently that designers have developed the facility with their new digital medium to exploit the possibilities of construction’ (Lynn, 2005).

This study is amongst the first to begin its creative exploration with a grounded literature survey as new approaches and tools for modeling new design processes. Beginning with simple principles of forces affecting the floating architectural design and formulating linguistic rule-bases to more complex three-dimensional exterior geometry.

This study is not just experimenting with linguistic variabled fuzzy logic language on floating architectural designs spatially but also tries to support new generation of architects with a new modeling tool that is very provocative, personal and innovative.

5.4. Findings for Tools

This section explains the tools as building information modeling as an information process, expert systems as a decision support and fuzzy logic as a design for decision support. These tools are to be used in evaluating the design process model of floating structures. There is a focus on tools because this period of experimentation has evolved into a new era focusing on precise and very digital design. Recently, softwares give designers the ability to talk to machines that can make things real. Consequently, in previous section, the possibility of the variety and freedom of form with these tools are understood. However, this section explores these new digital tools for their ability to be used from design to production. It tries to reassess the relationship between the designer and his tools.

This section also discusses the fuzzy logic as a software borrowed from a variety of design disciplines. It enables the design process modeling of floating architectural design with a new language giving names to the degree levels. Design, as discussed in this section, should be more than an expression of the technology that makes it possible and Weinstock (2010) states that architects are now in a period where evolution of form in nature and civilization can be seen widely in design works. By developing a link between physical and digital linguistic variables, rule-based process model evaluates its ability to develop the required forms. MacGrath (2008) states digital modelling for urban design became an urgent support in the decision process of architectural forms. The rules determined by experts take inspiration from their adaptivity to the environment limit conditions change. This is designed to make a feedback loop between design concept variables and external factors. Expert opinions and rule-bases are used and input data are analiyzed and evaluated until the design meets the performative criteria. (Ciftcioglu, 2009) This section is a synthesis of a process that seeks to resolve the problem of designing the form of the floating structure in conjuction with related parameters articulating that form. As the incorporation of complex forms and natural parameters becomes more and more effective in built floating architecture, the part to whole relationship will become increasingly more meaningful. This section is a modest step uncovering that meaning.

After this section, a case study is presented as a validation of the proposed design parameters.

6. APPLICATION OF MODEL AS CASE STUDY

This study has proposed an interesting and attractive solution for climate change and rising sea levels: floating architectural design process modeling with fuzzy logic linguistic variables supported by expert opinion. Expert opinion is needed because the analyses require both the knowledge of the wave-wind induced motions and the structure's dynamic response. Brown (2006) conducted studies about floating product systems in offshore structures and, Wu (2001) specialized more on innovations for superstructure of ship hulls. For the response of the superstructure to wind induced motions, aeroelastic analyses require time variant aerodynamic loading interacting with a dynamic structure. Both can be extremely complicated but this presents an entirely new challenge for the designer. These challenges will continue to limit the innovation in floating architectural design until adequate research is devoted to it and appropriate design tools are developed and evaluated. The proposed model for floating architectural design involving a logic driven expert opinion, provides a tool to understand and discuss the water-related phenomena without high engineering and mathematical calculations.

Judging the user comfort motion target performance of a floating architectural design requires the consideration of many facts. Fuzzy logic with expert assessments provides elemental information about the floating structure design. The expert assessments include making decisions of motion comfort target levels of floating structure in changing environments. However, when decisions are taken, it is important to interpret and combine the results from the tools (Ciftcioglu, 2009). This way, the availability of the solutions is discussed in a more holistic manner. Evaluating this process is better in early design stage, where uncertainty is high, and the effect on subsequent process phases are crucial.

This section presents a case study as a validation of the proposed methodology. It is a meta-evaluation that makes use of fuzzy sets and fuzzy logic. It provides a data collection tool for the proposed fuzzy inference system of a floating structure. The tool presents intermediate answers for the problems of a floating design and provides the ability to adapt to dimensional change because of specific environmental needs; and gives transparency, through the use of linguistic rules that facilitate both the understanding and the discussion of the whole processes. The rules are based on expert opinion and literature review of the research section. The proposed model supports designers, who may lack experience in meta-evaluation in the design process of floating structures.

6.1. Floating Yacht Club and Sailing School Design Application with Matlab

The floating architectural design process model is used in this study for the design process of floating yacht club and sailing school in Kalamis, Istanbul as a case study. In Figure 6.1 Kalamis, Istanbul, Turkey, the case study area as a floating sailing yacht club and sailing school can be seen. The layout plan is arranged in a manner that the floating structure is stabilized with tension legs in the bottom of the Marmara with a depth of 5m and 20m away from the coast line and it is connected to the coast line with a floating bridge in Figure 6.2. The environmental parameters for the design process model of the floating yacht club such as wind data and wave characteristics data are taken from the north-east Marmara sea region data. Consequently, the dimensional properties of the floating yacht club are arranged initially according to the given program of the client and then analyzed and evaluated through the proposed rule-based design model. The data of environmental requirements and their correlation with the structural dimensions are applied to the design process model in a computer program called Matlab.

Figure 6.1 : Kalamis, Istanbul, Turkey, case study area.

All wind-wave induced correlation parameters are applied to the fuzzy linguistic variables in ‘Matlab’ program and the changes in the data affecting human motion comfort target levels are analyzed and evaluated with expert opinion.

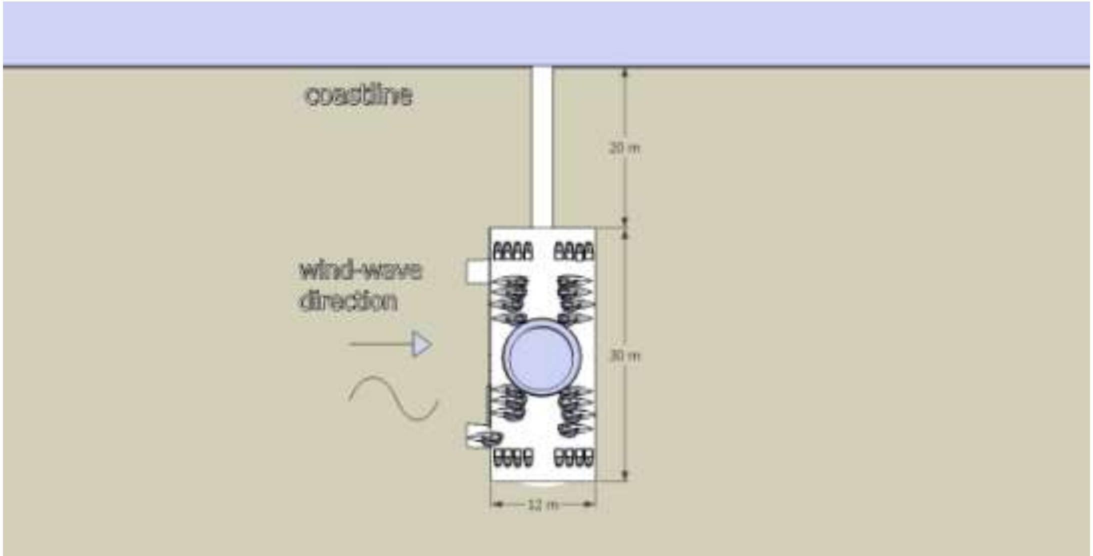


Figure 6.2 : Layout plan for the case study.

The floating structure’s superstructure dimensions and geometry, floating structure’s freeboard height and floating structure base’s width length are planned according to those parameters affecting the whole body design dimensions of the floating structure. The design process modeling of floating yacht club uses Matlab computer program in Mamdani. In Figure 6.3, the dimensions of the floating yacht club elevation from the sea is indicated.

Every required dimension in the proposed model refers to a certain design aspect correlated with environmental forces. Using this model, the user performance motion comfort target levels threatening health are controlled with respect to multiple changeable dimensions in the concept design phase. The suggested tool for computing with linguistic concepts is fuzzy logic. The uniqueness of this study comes from the fact that this has not been achieved before since computation as a design decision support conventionally deals only with crisp numeric information. However, fuzzy logic systems are not generally used in handling multiple dimensions and it was not possible to make use of any expert knowledge in floating architectural design in a computational system. A special fuzzy information processing method is evaluated in this study. In this way, the model can be accepted as a decision support for multi-dimensional performance-based design models.

The environmental conditions, performance parameters and dimensions of the structure are converted into a complex algorithm with fuzzy logic that provides a tool to simply assist the designer to see all the possible set of solutions to meet the required objectives that are also set by the designer. So, the tool turns out to be a decision support, leaving the designer to make the final decision. Every solution has its own degree of performance and a decision maker selects among them with great confidence. As the rule-bases are formed, alternate designs can be explored by varying parameters. The evaluated system can handle up to three objectives. In the future, the amount of variables can be increased, depending on available expertise with appropriate computational time.

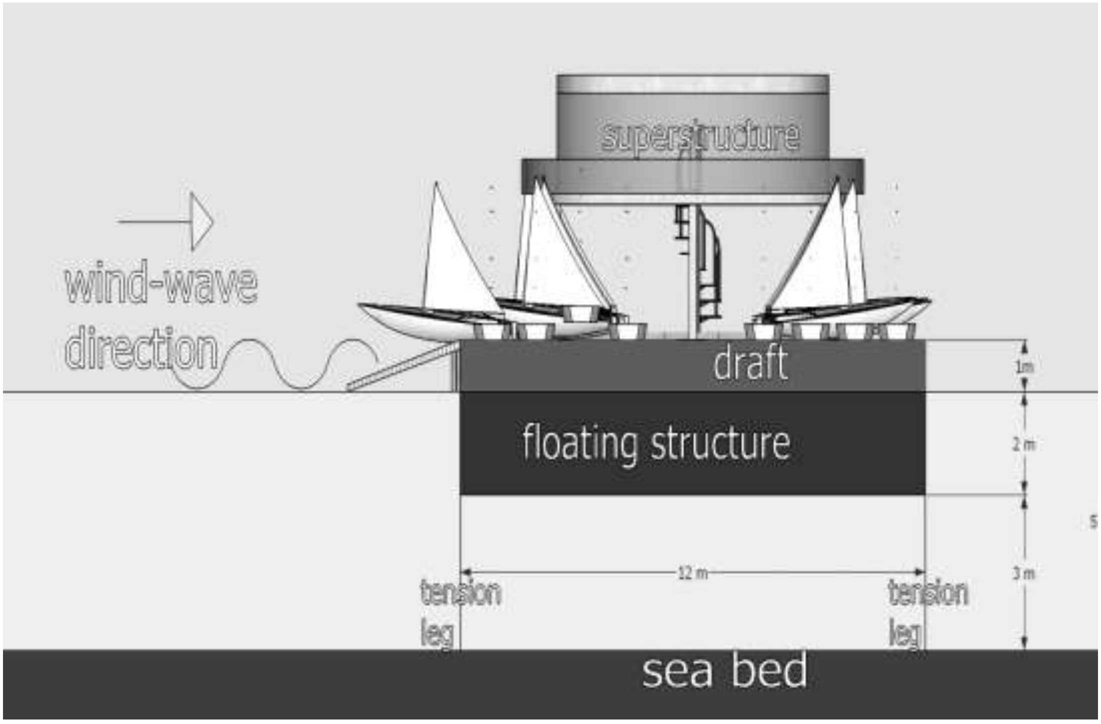


Figure 6.3 : Elevation for the case study.

Finally, the approach of the study is one of the kind where human decision maker is setting the criteria and fuzzy logic linguistic variables provide optimal rule-bases for these parameters. Based on rule-based solutions, the decision-maker modifies the dimensions of the structure until a desired solution matches the designer’s complete preferences. (Ciftcioglu, 2009)

The program of the sailing school is prepared with the sailing club’s founder. Sailing school would be giving optimist, laser and yacht sailing courses. The reason for the need of a floating sailing school is stated as ‘there is no place on the seaside of Kalamış for an appropriate sailing club because of high rates’. Perspective of floating yacht club and sailing school can be seen in Figure 6.4.

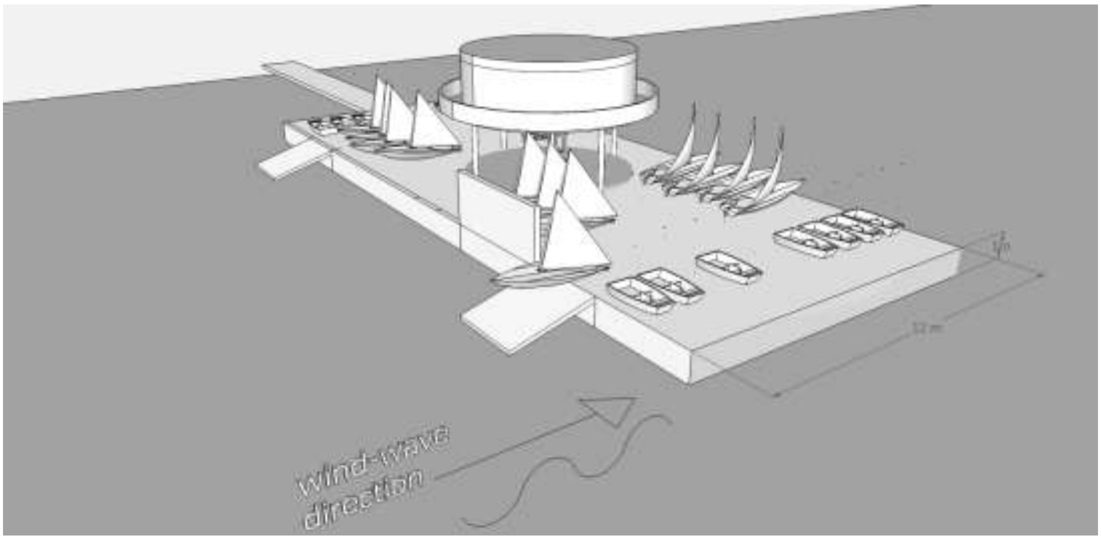


Figure 6.4 : Perspective of case study.

According to the program of the floating sailing school of the case study, the floating structure will have a space for:

- The floating base dimensions are arranged to achieve the capacity of 20 Optimists and 15 Lasers. The building will be around 30 m-12 m according to laser and optimist dimensions.
- The superstructure's first floor will be for sailing courses without affecting the scenery and the form of the superstructure is designed according to the wind –force correlated with superstructure form and area parameter. In order to reduce wind-force, the floating base is also used for courses. Maximum 80 people are considered as live load. The first floor live load is of maximum 45 people. The first floor is for adult courses and the ground is for children courses. The first floor dimensions are 5m x 5m total 25m^2 with max. 45 people.
- The North-east of Marmara Sea wind and wave characteristics are taken as the environmental limit conditions of the study. Accepted wave height is between 0,5 m-3,00 m.
- The building will be designed for 1.5 m wave height. Freeboard height is designed according to the wave-height freeboard height correlation parameters. However, freeboard height is also designed as to provide laser and optimists perfect landing to the sea level. Consequently, 2 ramps for laser and optimists are designed for landing sea.

- Maximum 3 m wave height occurs once a year. So, when it happens, the building will lose its weight while pumping out the water from water tanks.
- The whole building is designed with mobile walls to protect the floating structure from the dominant wave direction rise, which happens twice a year.
- The floating building will be placed mostly in Kalamış, 2 months around Florya and Dragos, and near Prince's Islands. So, it will be designed for the changeable conditions of these three places.
- The floating building will be 20 m away from the coastline to have a water depth of 5 m. The ground on which floating structure will be moored has soft ozzy property.
- The dimensions of floating building and the freeboard height is designed according to the proposed model. However, following the concept design, only the correlated freeboard height dimensions can change within an interval according to wave and wind and motion effects.
- Consequently, freeboard height is determined according to the wave height parameter and structures' width length that is determined according to the wave-length parameter, the superstructure area and its form is determined according to the wind-force parameter of the proposed model. The proposed model is used as a decision support in determining correlated dimensions.
- All these dimensions are calculated depending on the required program and with the support of the lingusitic expert opinion rule based fuzzy logic system.
- Using Matlab (computer program for fuzzy logic rules), the case study will show designers how to use the model and the philosophy so as to allow them to configure their own rules for their own design problems.

'Our interracton with the world can be thought of as a mixture of these two responses: accept or change' (Vitruvius, Theophrastus). Like language, architecture is not stagnant. Both architecture and language exist through use and are subject to changes and variations. Designing minds combine change and acceptance in varying degrees. In some products of architecture, the attitude of change and control seems to dominate whereas the attitude of acceptance and responsiveness prevail in others.

Consequently, the following phases are considered in the study before gathering the preliminary findings:

- Research Phase-Information and Solution Search: Ideas for solutions on a concept or embodiment design level
- Approach Phase - Limit Conditions Phase: Goal analysis and goal decision; clarifying concept or embodiment determining requirements
- Tools Phase - Application Phase: Analysis of solutions and decision making; analysis and decision-making concept and embodiment design

'Computing with words' is a contribution of fuzzy logic to artificial intelligence concept. It became feasible through using linguistic variables, where the words can be interpreted as semantic labels to the fuzzy sets, which are the mechanism of fuzzy logic. Consequently, human comprehensible computer representation of the domain issues can be created.

In 80s, symbolic logic associated with fuzzy logic helped the progress of artificial intelligence through expert systems. Today, human comprehensible computer representations are still in progress. In 90s, computational intelligence concept became one of the key areas of artificial intelligence, where the computation is not with words but numbers. However, the words are transformed to numbers through fuzzy logic, and the computations are made with fuzzy computations via fuzzy sets.

This new domain of computational intelligence through fuzzy logic is accepted as soft computing. Dealing with fuzzy qualities quantitatively is a significant step in artificial intelligence.

The type of fuzzy models varies according to the area used. In some applications, qualitative aspects may play an essential role while numerical properties are more dominant in some other applications. In this study, the qualitative aspects are taken as prior aspects. Both the interpretability properties and numerical properties are important aspects of fuzzy modeling, while the gravity is still dependent on the application. In engineering systems, generally fuzzy models are data driven. However, the statistical aspects of fuzzy modeling draw relatively less attention than the aspects of computing with words and soft computing. Computing with words and soft computing are two aspects where Mamdani type of fuzzy models are more convenient in addressing soft issues, especially in soft domains. Integrating the linguistic information or expert knowledge into architectural design are non-linear models. The fuzzy model in this study is considered as the representation of a general non-linear dynamic system.

This study presents the effectiveness of fuzzy logic for non-linear modeling of floating architectural design process modeling under the case study of floating yacht club assembled in Kalamis, Istanbul. The present research addresses the issue of understanding the main features of fuzzy logic in non-linear modeling application of floating yacht club design in the context of dynamic system modeling. This is achieved by processing the uncertain environmental variables taken as inputs through the nonlinear system modeled by fuzzy logic. The modeling performance is investigated and discussed in relation to the degree of non-linearity of the model in line with expert opinion. In addition, the study forms the principles of linguistic scheme in decision support modeling of floating architecture with a consideration.

Expert views are used in the study to learn from the past. By using fuzzy logic as the decision support and the work of predicting of the future results of our design preferences and changing it according to the results to improve the quality of design can be achieved.

Fuzzy logic is the most popular constituent of the soft computing area since they are able to represent the human expertise in the form of IF-THEN consequent statements. System behaviour is modelled through the use of linguistic descriptions. Sen (2010), have adapted fuzzy approach to identify the effect of wind speed on wave characteristics variations in ocean wave generating systems.

After discussing the general parameters affecting the concept design of floating architecture, the motion user comfort target is accepted as the primary parameter to be discussed in the study. Human biodynamics and human comfort conditions under motion effects are discussed within the rule-based design process modeling. The parameters affecting the motion comfort target levels in floating architectural structures are listed in the following tables of the Matlab application.

In recent years, the research interest in artificial intellegence and fuzzy logic as decision support system has increased and many efforts have been made for the applications to various coastal engineering problems. The most significant features of fuzzy logic are the extreme flexibility due to learning ability and the capability of non-linear function of approximations. These facts lead us to accept fuzzy logic to be an excellent tool for solving the motion comfort target levels of floating structures, while overcoming complexity and non-linearity associated with wave construction interaction. In Figure 6.5, fuzzy logic model of the study can be seen with the relationship graphic of the performance-dimension based criteria.

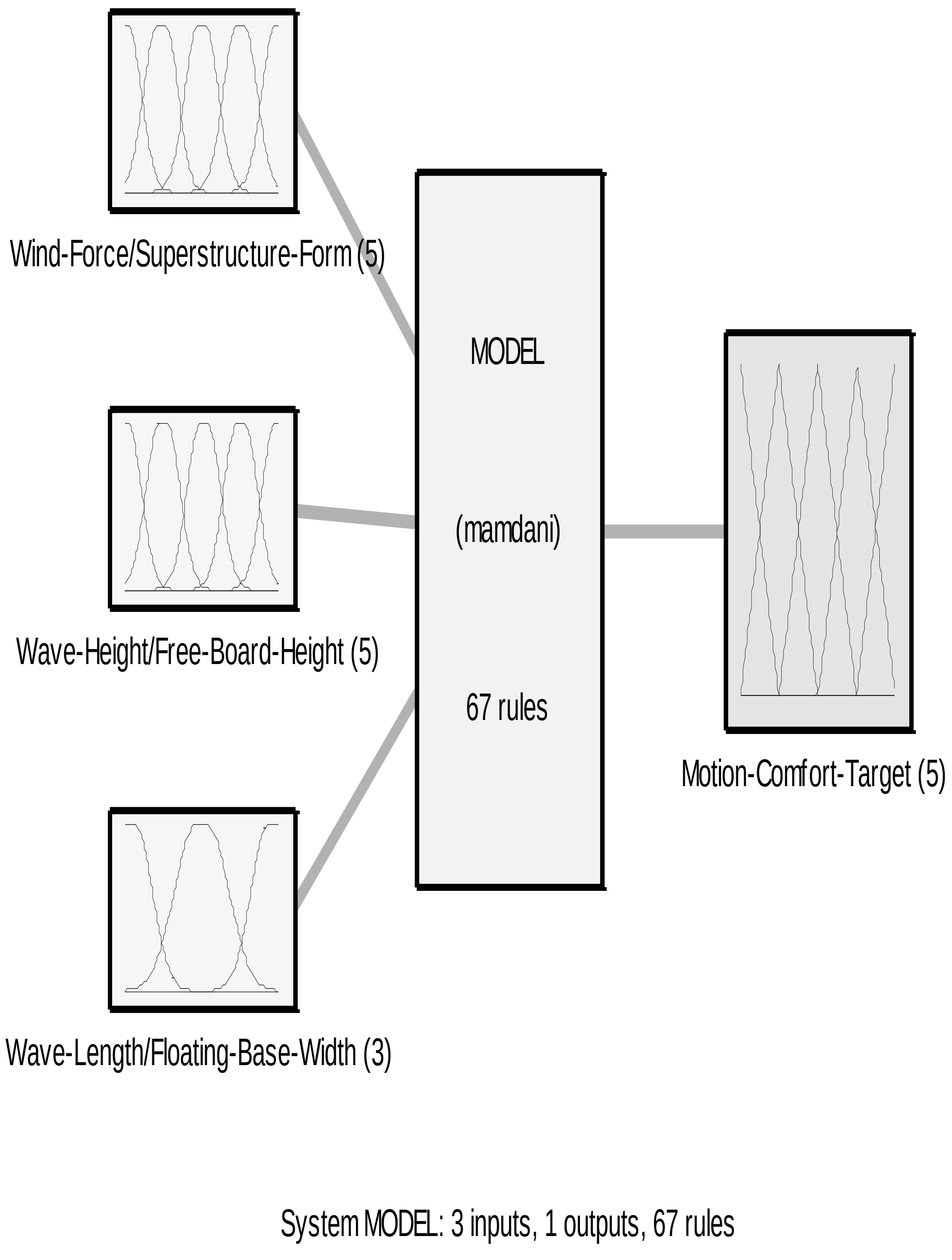


Figure 6.5 : Fuzzy logic model in Matlab.

The fuzzy logic variables used in the study to address the five degree value system (worst, bad, average, good and best) can be seen. To give an example of the the rule based system;

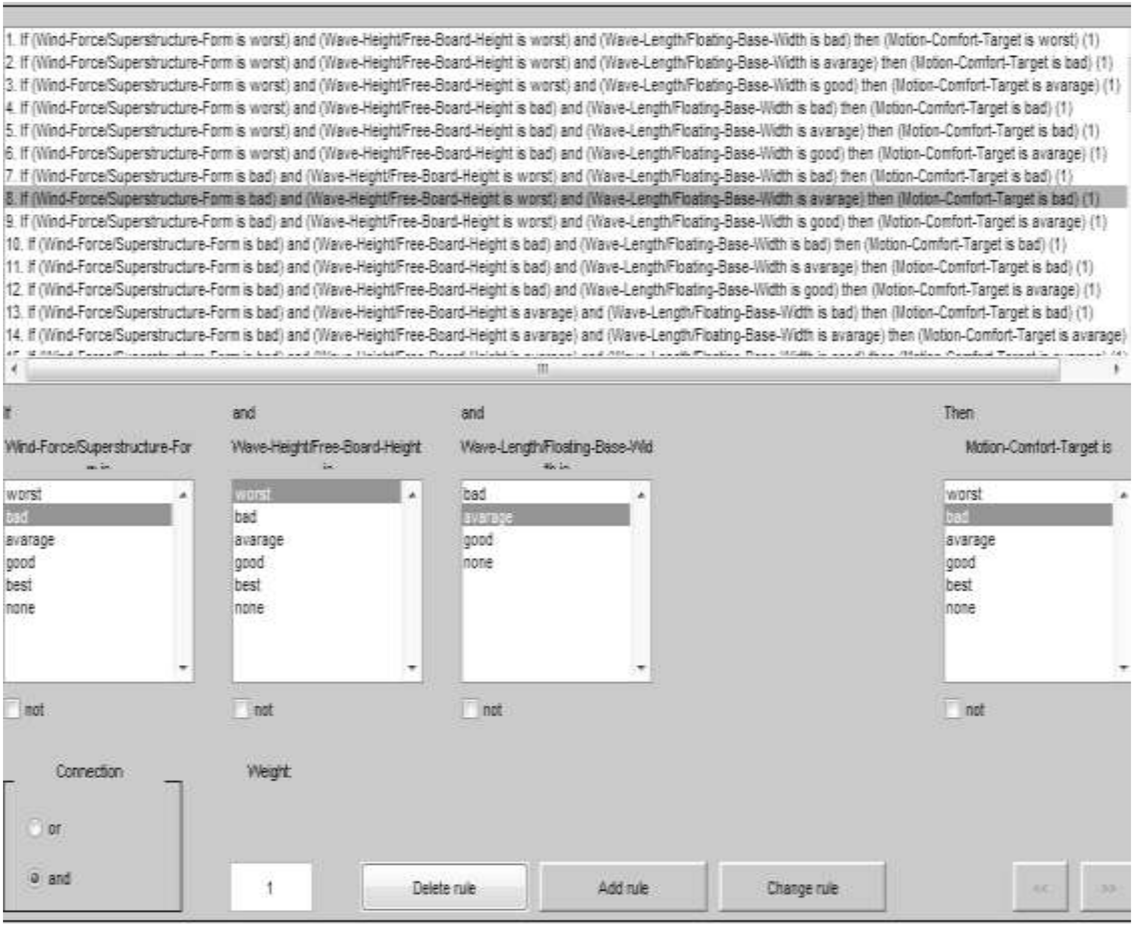
- IF ‘wind force correlation with superstructure area’ is bad and ‘wave height correlation with freeboard height’ is bad and ‘wave length correlation with floating structure base width’ is bad, THEN ‘motion comfort target level’ is bad,
- IF ‘wind force correlation with superstructure area’ is average and ‘wave height correlation with freeboard height’ is good and ‘wave length correlation with floating structure base width’ is good, THEN motion comfort target level’ is average.
- IF ‘wind force correlation with superstructure area’ is good and ‘wave height correlation with freeboard height’ is bad and ‘wave length correlation with floating structure base width’ is average, THEN motion comfort target level’ is average.

Sivanandam (2007) states that fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. These IF-THEN rule statements are used to formulate the conditional statements that constitute the fuzzy logic. A single fuzzy IF-THEN rule assumes the form IF x is A, THEN y is B where A and B are linguistic values defined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. The IF-part of the rule "x is A" is called the antecedent or premise, while the THEN-part of the rule "y is B" is called the consequent or conclusion. In the IF-THEN rule, the word is used in two entirely different ways depending on whether it appears in the antecedent or the consequent.

The most important thing for fuzzy logic reasoning is the fact that it is a superset of standard Boolean logic. In other words, if you keep the fuzzy values at their extremes of 1 (completely true), and 0 (completely false), standard logical operations will be achieved. At the extreme values of fuzzy values, standard logical operations will be achieved AND can be defined by MIN (minimum) operation OR can be defined by MAX (maximum) operation as declared by Koivo, (2006). Moreover, because there is a function behind the truth table rather than just the truth table itself, values other than 1 and 0 can be considered. Given these three functions, any construction using fuzzy sets and the fuzzy logical operation AND, OR, and NOT can be solved. Typically, most fuzzy logic applications make use of these operations. Fuzzy Logic

Toolbox also enables customization of the AND and OR operators. In Table 6.1, some of the fuzzy rules can be seen of the proposed design process model in Matlab program.

Table 6.1 : The rules of the proposed model in Matlab.



Fuzziness in a fuzzy set is characterized by its membership functions. A membership function (MF) is a curve that defines, how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1 (Matlab fuzzy logic toolbox tutorial).

There are 11 functions, which are commonly used in fuzzy logic applications. These are, in fact, built from several basic functions: piecewise linear functions, the Gaussian distribution function, the sigmoid curve, quadratic and cubic polynomial curves. The simplest MFs are formed using straight lines. Of these, the simplest is the triangular MFs. It is a fuzzy number represented with three points. The trapezoidal MF has a flat top and really is just a truncated triangle curve. The straight line MFs have the advantage of simplicity. The generalized bell membership function is specified by three parameters. Because of their smoothness and concise notation, Gaussian and bell MFs are popular methods for specifying fuzzy sets. Both of these curves have the advantage of being smooth and non-zero at all points.

The selection of which MFs will be used is one of the fundamental issues associated with the application of fuzzy set theory. There are no guidelines or rules that can be used to choose the appropriate membership generation technique. The problem of MFs generation is crucial because the success of an algorithm depends on membership functions that are used (Medasani, 1998). There are various methods to assign membership functions to fuzzy variables. The approach adopted for acquiring the shape of any particular MFs is often dependent on the application. For most fuzzy logic control problems, the assumption is that the MFs are linear – usually triangular in shape. Once the shape is determined, the problem of determining the parameters that define the selected shape arises. Whether the shape and parameters selected are suitable for the problem to be modelled have to be elicited directly from the expert by a 'statistical' approach or by automatic generation of the shapes. This study uses expert opinion. In Figure 6.6, wind force and superstructure form correlation application in Matlab application is described. Here the MFs are gaussian. In Figure 6.7, wave height/freeboard-height correlation application is described in Matlab.

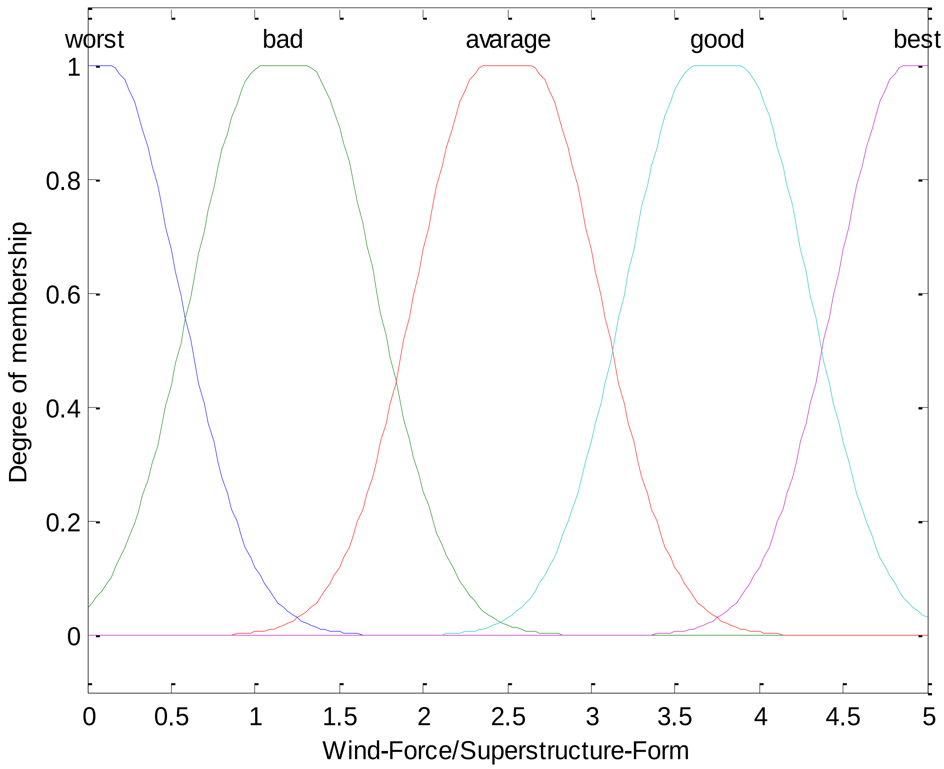


Figure 6.6 : Wind-force superstructure form correlation application in Matlab.

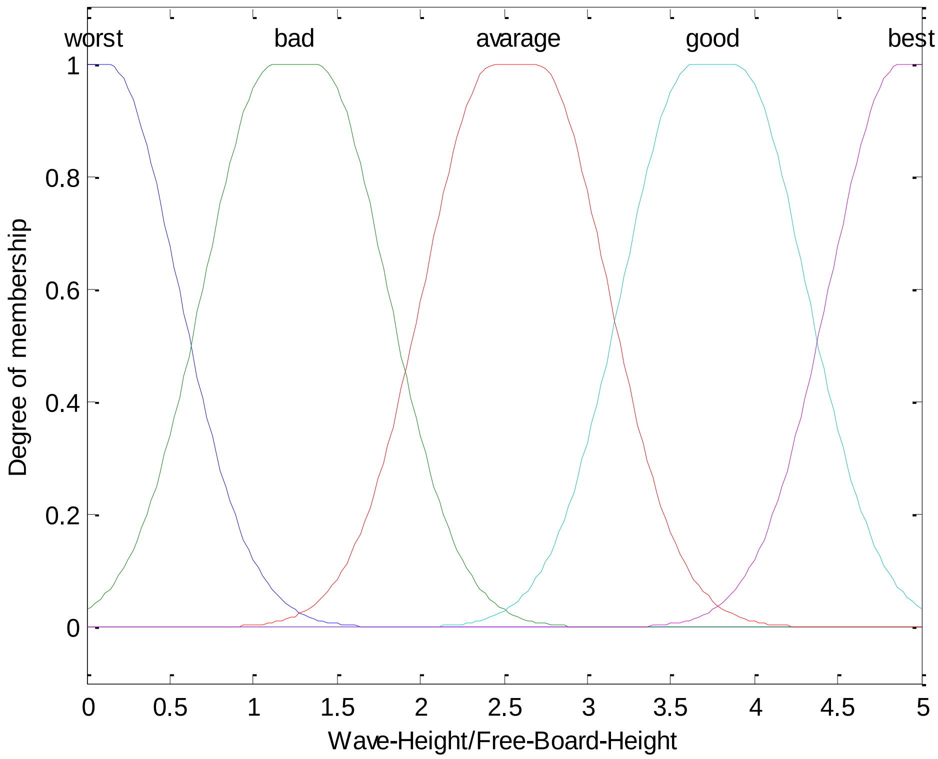


Figure 6. 7 : Wave height/freeboard-height correlation application in Matlab.

In Figure 6.8, wave length/floating base width correlation application in Matlab is described. Here the MFs are triangular.

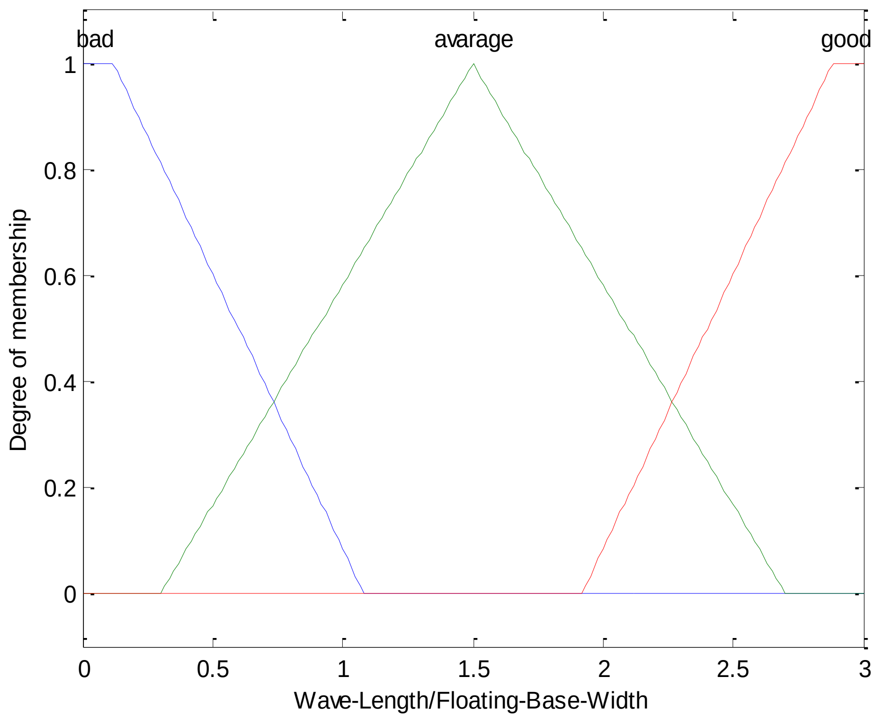


Figure 6. 8 : Wave length/floating base width correlation application in Matlab.

The methods for assigning the membership values can be listed as: rank ordering or statistical techniques, polling, direct rating, reverse rating, interval, estimation, membership exemplification and pair wise comparison.

The inference method involves the knowledge of deductive reasoning. The MF is formed from the known facts and knowledge. This study uses inference to assign the membership values.

All these methods depend on questioning the user in order to gain information and build a MF. As stated earlier, using experts is the most common way to determine MFs.

In Figure 6.9, user motion comfort target output application in Matlab is described. The MFs of the user motion comfort target levels are triangular.

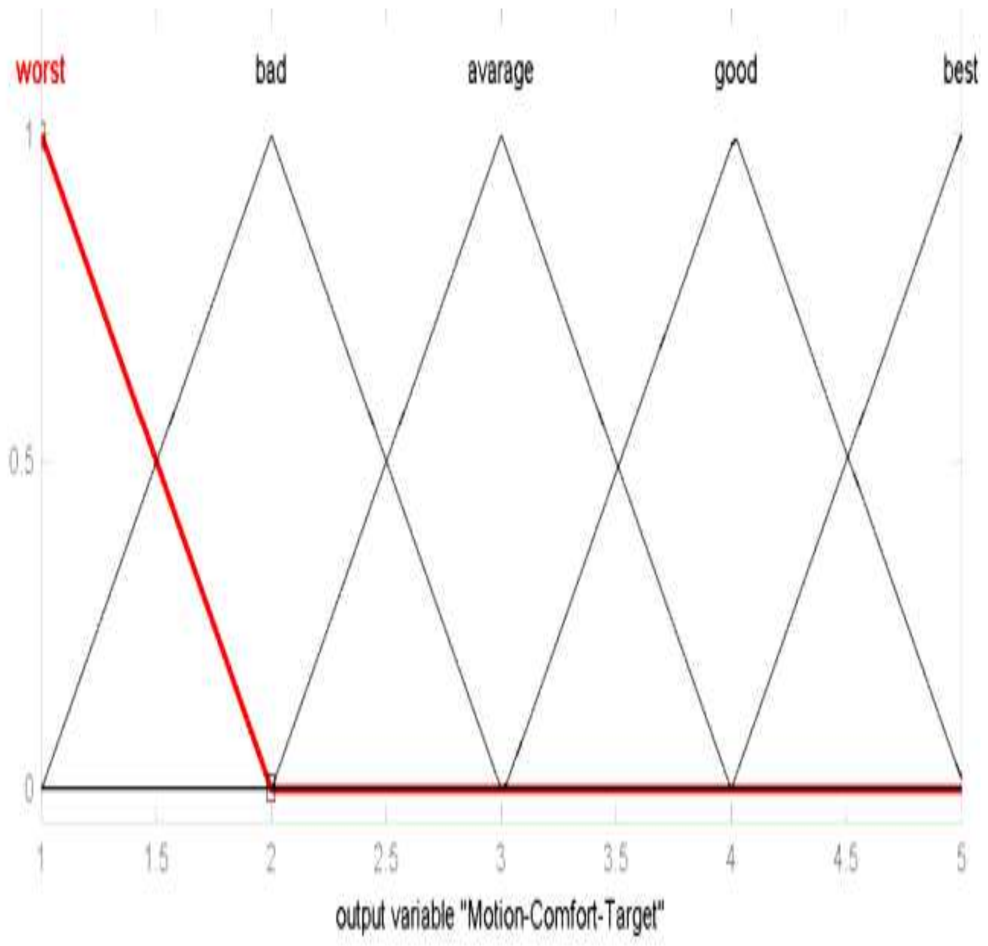


Figure 6. 9 : User motion comfort target output application in Matlab.

The steps of fuzzy reasoning (inference operations upon fuzzy IF-THEN rules) performed by FISs are:

1. Compare the input variables with MFs on the antecedent part to obtain the membership values of each linguistic label (fuzzification)

2. Combine (through a specific t-norm operator, usually multiplication or minimization) the membership values on the premise part to get weight of each rule

3. Generate the qualified consequences (either fuzzy or crisp) or each rule depending on weights

4. Aggregate the qualified consequences to produce a crisp output (defuzzification).

The input for the defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number. Although fuzziness helps the rule evaluation during the intermediate steps, the final desired output for each variable is generally a single number. However, the aggregate of a fuzzy set encompasses a range of output values. So, it must be defuzzified in order to resolve a single output value.

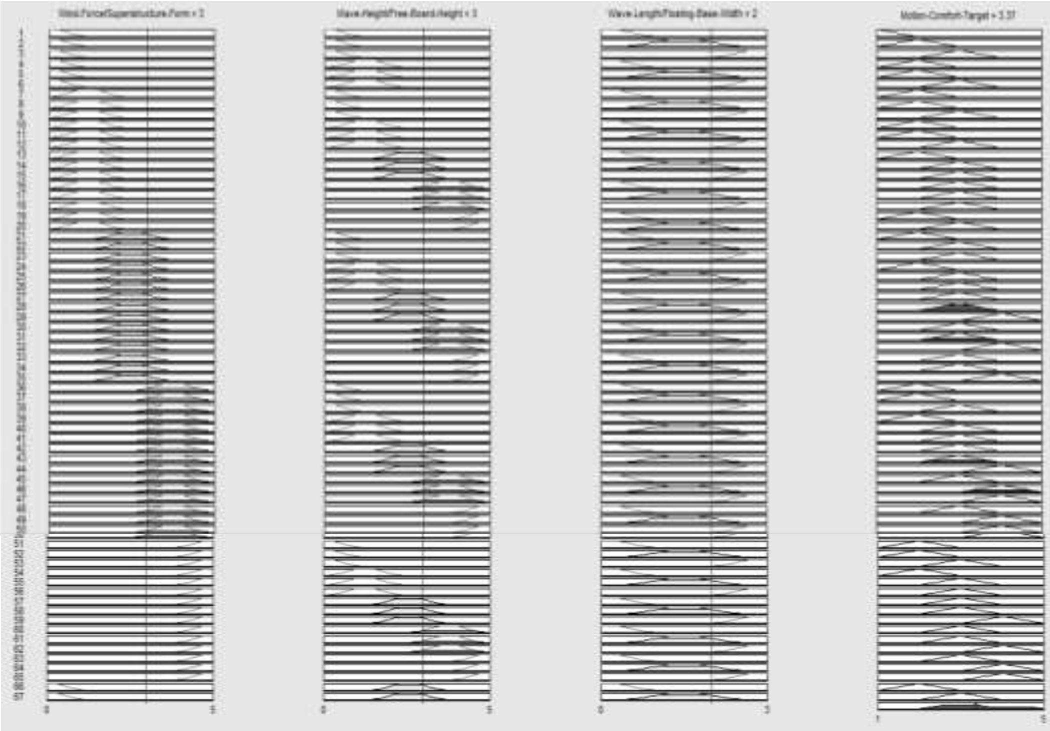
There are five built-in methods supported: centroid, bisector, middle of maximum (the average of the maximum value of the output set), largest of maximum and smallest of maximum. The most popular defuzzification method is the centroid calculation, which returns the center of area under the curve which is used in this study.

The working of FIS is as follows:

1. The crisp input is converted into fuzzy by using fuzzification method.
2. After fuzzification, the rule base is formed.
3. The fuzzy rule base and database are jointly referred as knowledge base.
4. Defuzzification is used to convert fuzzy value to the real world value, which is the output.

In Table 6.2, rule viewer application of the proposed process design model in Matlab can be seen.

Table 6.2 : Rule viewer application in Matlab.



In Figure 6.10 surface viewer application in Matlab for parameters, wave-height/freeboard-height to parameter, and wave-length/floating base-width can be seen. This shows that the wave-height/freeboard-height parameter and the wave-length/floating base-width parameter MFs are valid at this point and can be used for the evaluation of the process design model for the floating architectural structures to reach the determined level of motion comfort target level.

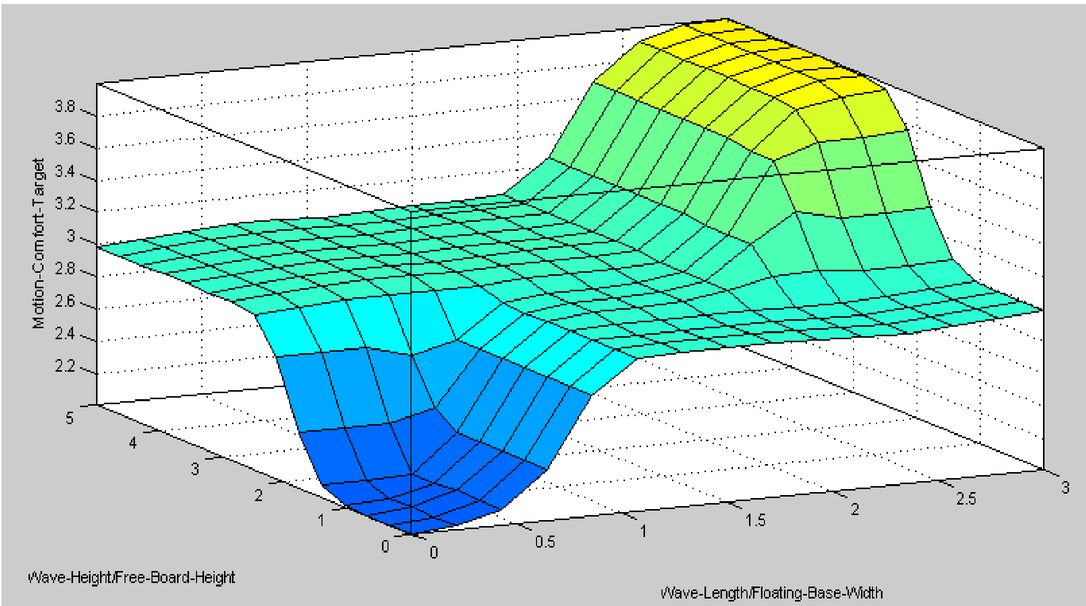


Figure 6.10 : Surface viewer wave height and length.

In Figure 6.11 surface viewer application in Matlab for parameters, input; wave-length/floating base-width to input and wind-force/superstructure form can be seen. This shows that wave-length/floating base-width parameter and wind-force/superstructure form parameter MFs are valid at this point and can be used for the evaluation of the process design model for the floating architectural structures to reach the determined level of motion comfort target level.

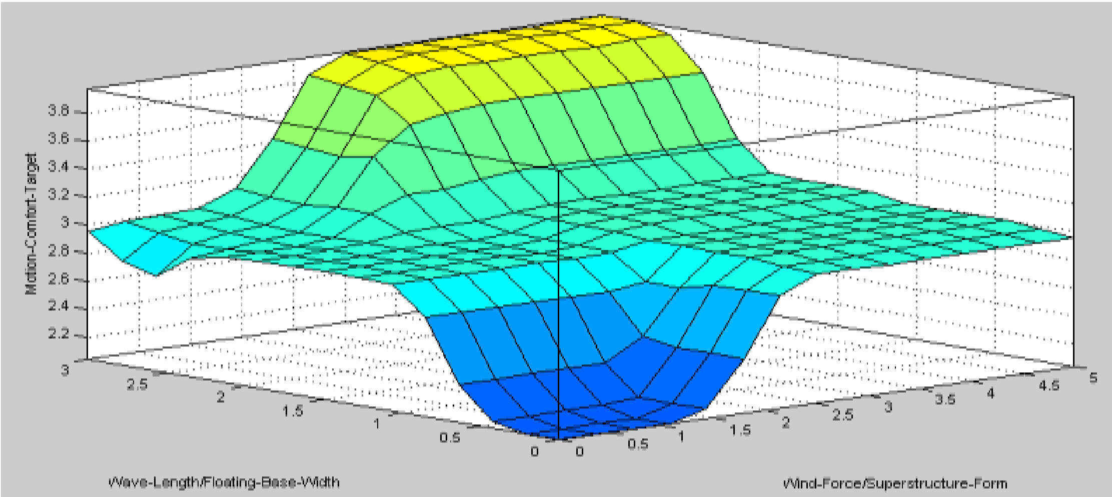


Figure 6.11 : Surface viewer for wave-length and wind-force.

In Figure 6.12 surface viewer application in Matlab for input, wave-height/freeboard-height to input and wind-force/superstructure form can be seen. This shows that wave-height/freeboard-height parameter and wind-force/superstructure form parameter MFs are valid at this point and can be used for the evaluation of the proposed design model.

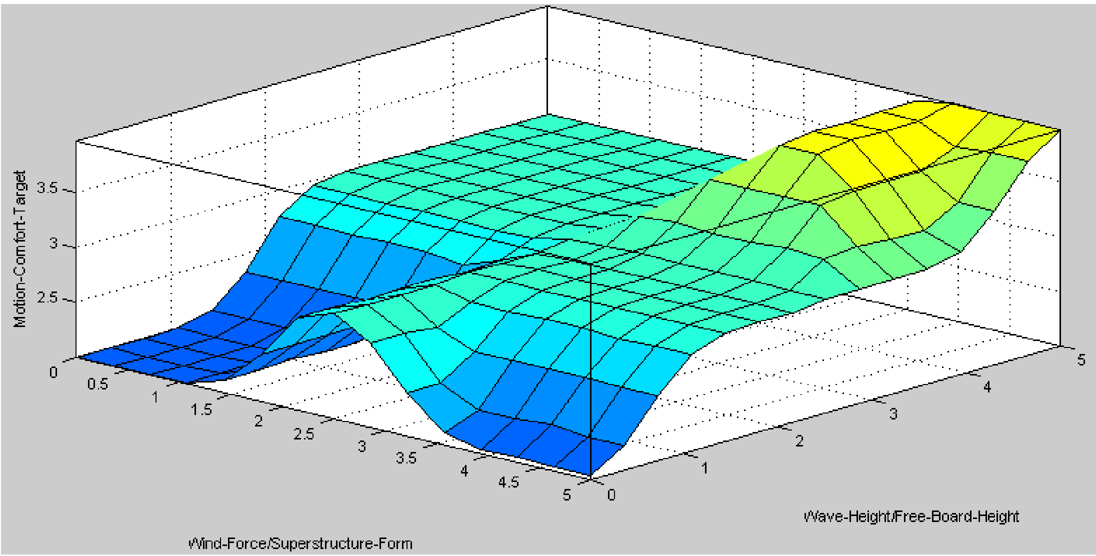


Figure 6.12 : Surface viewer for wave-height and wind-force.

In Table 6.3, 11 simulations out of 1000 simulations are listed as an example. 1000 simulations of proposed model include randomly distributed values within the interval of minimum maximum input values which are determined for the system parameters of the case study.

Table 6.3 : 11 Simulations out of 1000 randomly distributed values.

try	wave height	freeboard height	height ratio	wind velocity	form coefficient	air density	area	wind force	wave length	floating width	ratio	stability	MOTION EFFECT
MIN	1	1	6,0000	1	1,2	1,255	50	38	1	11	3,272727273	1	
MAX	6	6	0,1667	17	2,3	1,255	70	29197	36	15	0,066666667	3	
UNIT	m	m		m/s		kg/m^3	m^2	kg	m	m			
	random	random	correlation	random	random	constant	random	formul	random	random	correlation	crisp value	rule-based value
1	4,1050	3,3656	1,2197	1	1,2	1,255	54	41	16	11	1,454545455	2	1,979205176
2	5,9160	4,8127	1,2292	1	1,2	1,255	56	42	1	15	0,066666667	3	2,000153514
3	2,8263	3,0900	0,9146	1	1,2	1,255	59	44	28	15	1,866666667	2	3,000000256
4	3,9721	2,6732	1,4859	1	1,2	1,255	63	47	1	15	0,066666667	3	2,000243856
5	3,6339	1,8309	1,9847	1	1,2	1,255	63	47	13	14	0,928571429	2	3,000000256
6	1,4571	2,7478	0,5280	1	1,2	1,255	64	48	20	13	1,538461538	2	2,150494546
7	4,7848	2,9407	1,6271	1	1,2	1,255	65	49	25	14	1,785714286	2	2,000004978
8	5,9045	4,2932	1,3753	1	1,2	1,255	65	49	33	12	2,75	3	2,028956354
9	2,0029	5,7547	0,3481	1	1,2	1,255	65	49	29	12	2,416666667	3	3,000000259
10	5,0879	2,4425	2,0829	1	1,2	1,255	65	49	33	12	2,75	3	3,000000259
11	1,3825	2,8909	0,4782	1	1,5	1,255	53	50	15	12	1,25	2	[illegible]

In Figure 6.13 network model of 1000 simulations of from fuzzy controller to Simulink is stated.

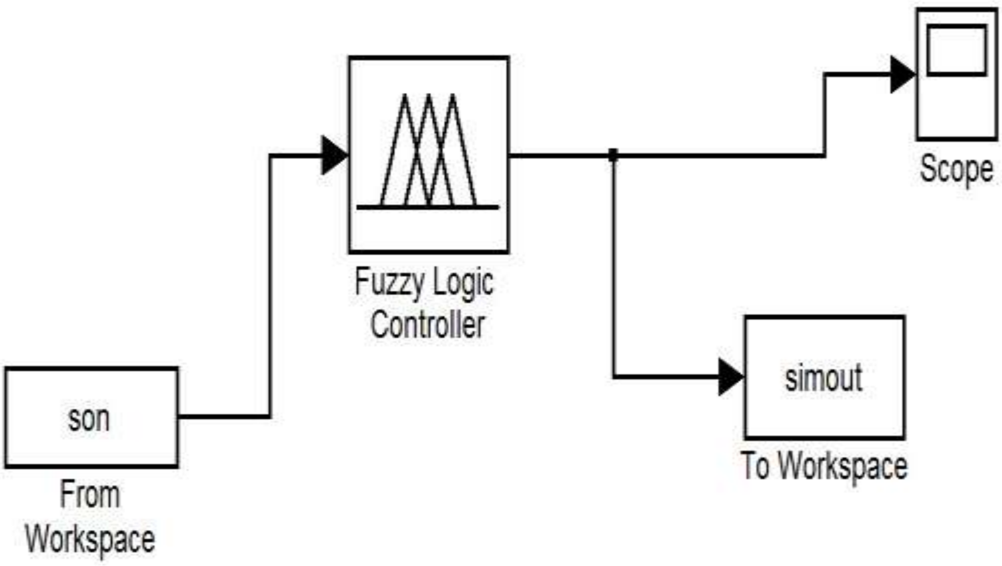


Figure 6.13 : Schema for making simulation of network of model.

1000 randomly distributed values can be seen in Figure 6.14 Scatter graphic for motion output target for freeboard height; form coefficient, area and floating base width input parameters within determined minimum maximum values for the case study can be seen. In scatter graphic where horizontal x axis is for the motion output target fuzzy linguistic degree variables and y- axis is for the model input parameters including freeboard height, form coefficient, area and floating base width within determined minimum maximum values for the case study. This is due to the individualistic characteristics of random dispersion, based on the idea that each design alternative has equal validity.

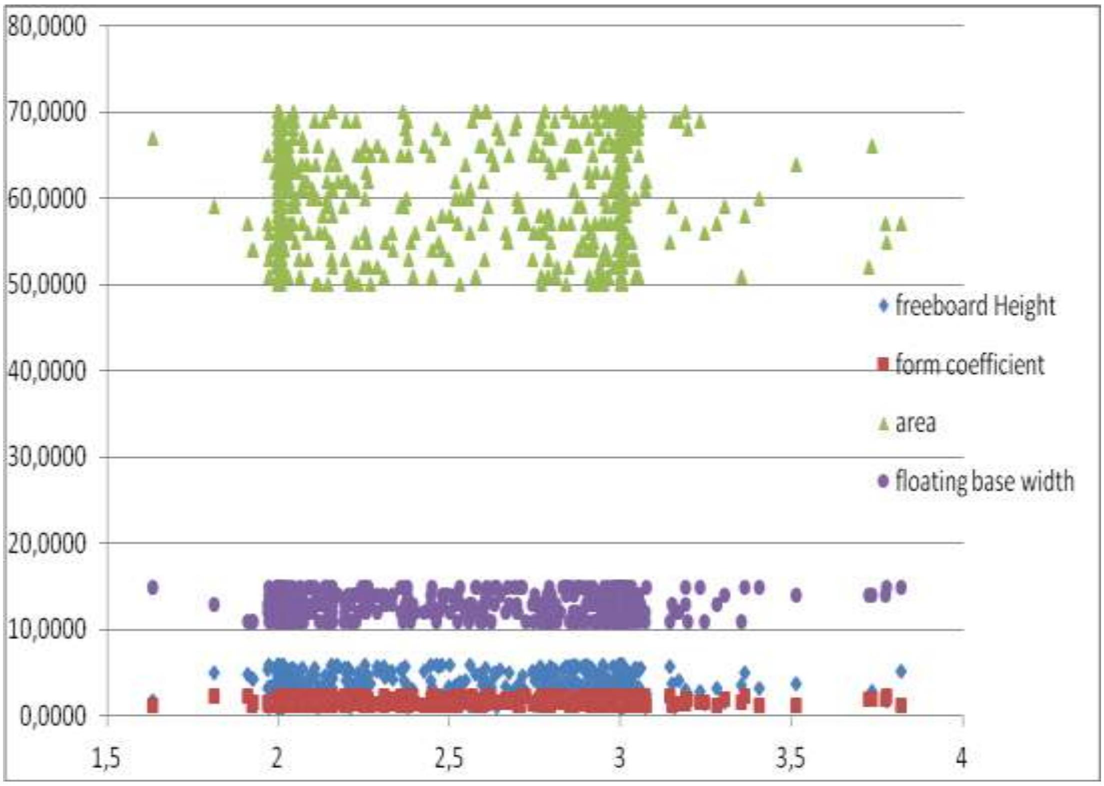


Figure 6.14 : Scatter graphic for output target.

For to display values for user motion comfort target levels, data is taken from the randomly distributed 1000 simulations. The output values of each correlated input value then applied into Matlab then Simulink where all input and output variables are listed as a scatter graphic. The architect analyze the data in a scatter plot, assigning user motion comfort target to the horizontal axis, and all the other input parameters which are controllable to the vertical axis.

Each of the dimensions for the freeboard height, the form coefficient, the superstructure area and the floating base width of a floating structure are represented in the scatter graphic in Figure 6.14. The scatter graph allows the architect to obtain a comparison of the variables in the 1000 simulations of randomly distributed data set, and supports the architect for to make decisions about the dimensions of the floating structure. As a further study, 3d design of the floating structure also can be obtained with an application of Rhino correlated with Grasshopper.

a. Case Study Findings

In the case study combination of vibration comfort and effective geometrical dimensions are analyzed. It became clear that communication with linguistic variables is critical in achieving levels of vibration performance of floating architectural designs. Similary, the complex network of information is critical to the work of experts in their fields upon intelligent communication, which is provided with the linguistic variables of the proposed design process model. The model needs a highly controlled network of communication among experts, designers and the machine. So, this case study provides a summary on how robotics and the associated languages of machines can be learnt by designers and in this way shows how this enables not only control, but also specialized expertise for decision support in floating architectural design. This not similar to learning a new language but more similar to learning a new techniqual approach to be used as a design skill. In the proposed model of the study, the architect is able to build a structure to the exact prescription of a floating architectural design under motion-induced loads preventing hazardous motion effects, fluidly changing the geometrically determined dimensions of the floating structure base width, freeboard height and superstructure area and form characteristics by decreasing the dimensions whenever possible within the limits of the rule-bases of the design process model. In this way, the performative efficiency of floating architectural designs can be obtained. Through expertise of both the naval architect and the architect, the designer translates techniques across disciplines to exceed floating architectural user motion comfort target. The fuzzy logic is used as a tool for translating between the imagination of the architect and the requirements of construction under motion-induced loads, insisting that fuzzy logic clearly expands the realm of possibility in design. In this way, the required efficieny target can be met. So, it can be accepted that the digitally driven designs look to a new industry of high performance levels to tackle new challenges.

7. CONCLUSION

There is a need for evaluating models with a purpose of forming sufficient interfaces for floating architecture design processes models. A considerable amount of research has been made on the design process modeling of architecture; however, at present, adequate progress is not made in FADPM (floating architectural design process modeling) due to the fact that it involves different kinds of problems compared to the land-based architectural designs. Consequently, the evaluation of floating architectural design process model is accepted as crucial in this study. However, there appears to be questios in dealing with problems faced in the evaluation of model for design process of floating structures:

- What is the logic after the design process of floating structures?
- Can we make our own design process model with computerized systems?
- How can a designer without complex programming language knowledge make his/our her own decision support model?

In this study, floating architectural design process modeling is evaluated within a case study, developing a new design strategy while analyzing the behaviour of floating architectural structure under three dominant environmental effects. In fact, the aim of this research is to form a logical approach to develope a software to design a floating architectural structures. Consequently in this study, how a computerized architectural design process modeling program can be evaluated with rule-bases which are supported by expert opinion and symbolized with linguistic variables as a decision support in designing floating architectural structures is presented. As the first step, the crucial process schema is determined within the literature research, then dominant parameters are defined, and finally, a rule-based decision support system is generated with the assistance of two experts with more than twenty years field experience. By this way, the model is proposed and the process of configuration of the model is also described to encourage designers to make their own models in their own focus areas.

There are a limited number of papers documenting floating architectural structure response types to motion effects and there appears to be only limited work carried out on the evaluation and use of different metods herein. So, the objective of this study is to provide a target level of reliability and effectivity in behaviours of floating archtectural structures that are mostly under motion induced lateral loads such as wind and wave, having an uncertain behaviour pattern. Consequently, identifying the correlation of interface requirements between the geometrical dimensions of floating architectural structures and motion induced load effects, the work of reducing the uncertainties of the floating architecture design process is achieved. However, further work is required in this field to improve a proper understanding.

Floating architectural structures are used in an expanding range of water depths with different environmental conditions. To minimize and qualify uncertainty in these variable water depths, the water depth phenomena is excluded in this case study. However the safety and efficiency of the user motion comfort target of floating architetural designs are the focus objectives in the proposed decision-support model of the thesis, this proposed model also provides a unique and new set of architectural process design modeling challenges and preferences for the designers working in this field. For small size floating structures such as the case study of this study, these challenges are even more important.

Discussion in this study is about finding the best strategy for the management of environmental phenomena affecting dominantly the form design of the floating architectural structures. Environmental phenomena is mainly formed with wind-wave induced loads, which includes approximate values, incomplete and uncertain character. To cope with this approximity, the use of fuzyy logic variables are used as a rule-based decision support modeling for floating architectural design. The model is applied considering the priorities of the whole system behavioral response of floating structures, then all these process model priorities are discussed under the very changeable atmosphere of sea conditions. Furthermore, uncertain sea conditions knowledge is tamed with the use of fuzzy logic, which is accepted as sub-level of artifical intellegence, particularly in this study, the use of fuzzy logic in architectural space planning can be accepted as an initial step for the future study of the evolutionary computing approaches in architectural designs.

According to fuzzy logic system used in this study, the ‘user motion comfort target,’ in floating architectural design process is taken as a totally subjective degree by experts and thus, always depends on the designer preference. Fuzzy logic is used as a tool for providing a creative space for designers. Each independent designer has the freedom to design her/his own floating architectural design process model with their own preferences as they give different linguistic variables for the user motion comfort target degrees under wind-wave induced loads. So, the fuzzy logic is not the only way to calculate subjectively the probability of one senario, but it also provides a decision support for designers to calculate subjectively every scenario and within each scenario, there are unique linguistic variables translated to prefered target levels for the design process of floating architectural strcutures.

The research type of this study is applied research, its objective is exploratory and the type of information sought herein is qualitative.

1. Formulating a research problem:
   Applied research; motion effects on human comfort levels under mobility
2. Conceptualizing a research design:
   Multi-disciplinary and computational design process systems
3. Constructing an instrument for data collection:
   Fuzzy logic and linguistic decision support systems for design modeling
4. Selecting a sample
   Evaluation of floating architecture design modeling of Floating Yacht Club and Sailing School in Kalamış, Istanbul, Turkey is chosen as the case study
5. Research proposal
   User motion comfort is taken as the initial priority and discussed under the environmental parameters with expert knowledge, that frames the proposed rule-based decision support model for floating architecture
6. Collecting data
   Site-specific environmental data and recent literature in breakwater design
7. Processing data
   Application of data taken from case study in fuzzy logic used in Matlab, tested with Simulink

The intention of thesis is to discuss the information about floating structures and then, with the cooperative assistance of fuzzy logic, to compose a ruled based design method. Consequently, a future vision on computerized architectural designs is realized under the field of floating structures with a linguistic computer programming approach called fuzzy logic.

Fuzzy logic is accepted as a system that tries to use the way that humans use to solve a problem, learn a language or evaluate a thought, where there is no need for precise numerical input to make decisions, introducing a class with unsharp boundaries. The problem of this study involves information, that is provided with rules. A problem in fuzzy logic is usually solved using either a forward-chaining or data-driven systems that compare data in the working memory against conditions (if parts) of rules and determine which rules are to be eliminated. So, special interest is given in this study to the stochastic process of human thought.

One of the aims of the proposed model is to identify optimal solutions for the determined multiple criteria involving linguistic concepts and systematically getting the most suitable solution amongst alternatives. It is said to be the reasonning process of fuzzy logic and the aim is the dynamic control of the relationships between variables and modeling the dynamic geometry and in this way, understanding the active effect of disciplines, apart from the architecture itself, on the design process. This idea aims to explore design areas in a multidisciplinar way due to the fact that architecture is a hybrid product synthesized of multiple branches of knowledge.

Given the fact that the idea of process requires more maturity than the product itself, the primary aspect of modeling in this study is transforming the uncertain data of floating architecture to linguistic variables to form an appropriate human designed decision support system. The design parameters are incorporated into a complex algorithm, which finds the best set of solutions to meet the objectives set by the designer. The crisp numeric information is converted to linguistic concepts, in this way, 'expert knowledge' is used by developing a special fuzyy information processing system.

The stochastic modeling is used in architectural design of floating structures; however, it is also studied in other disciplines such as business management, computer science, engineering, operations research, public policy, statistics and mathematics. As the title of this thesis suggests, this study addresses three dominant parameters (wind, wave height and wave length), using stochastic fuzzy logic methodolgy to study real system behaviour of the response limits of floating architectural structure, under very changeable atmosphere of environmental conditions.

This study employes a case study to explain how to build a stochastic model of a floating structure and analyzes the proposed model to predict user motion comfort target levels and uses this analysis to design and control the related dimensions of the floating structure. The proposed model is illustrated with schemas and the study emphasized quantitative and linguistic answers to the determined floating architectural design's motion comfort target problem.

The process shcema of this study:

- Research:
  - Importance of floating architectural design process modeling
  - Floating architectural design context
  - Problems in design process modeling of floating architecture
- Approaches determination:
  - environmental architecture; wind-wave induced motion effets
  - performance based architecture; motion user comfort target
  - new product development; the process schema of research phase, approach phase, limit conditions phase, tools phase, application phase
  - product to process models; wind-wave and motion effects correlated with floating architectural design dimensions
- Limit conditions:
  - Motion comfort target characteristics of floating architecture
  - Wind velocity to superstructure area and form correlation
  - Wave height to freeboard height correlation
  - Wave length to floating base width correlation
- Tools:
  - building information management

    - expert knowledge
    - fuzzy logic rule-based decision support
- Application case study of floating yacht club and sailing school in Kalamis, Istanbul, Turkey design process modeling with Matlab and Simulink

In the proposed model, the first step is understanding the process on which a real floating architectural system operates. Assumptions which are simple yet sufficiently true to the real system are formed with approximate credibility. In this study, this step is emphasized repeatedly with the use of fuzzy logic and new product development and product to process modeling processes, which are also assumed as stochastic processes.

Analysis of the approaches is the second step. A careful analysis of the model problem and correspondent approaches to compute the required answers are determined. To facilitate this step, this study discussed special classes of stochastic approach types.

The third step is determining the limit conditons in design process modeling of floating architeture. The limit conditions of the proposed model are described by a small number of parameters, which are dominant in the design of floating structures. However, the real focus is given to the evaluation process of the decision support system and determining the prefered values of these parameters so as to give an opportunity to the designer to configure his/her own process model. For each of these limit conditions, tools are chosen to compute involving a computer system that uses matrix oriented languages such as Matlab. The user comfort vibration performance of the system is generated as a function of the determined system parameters using the fuzzy logic, expert knowledge and building information systems as tools developed herein. Then the appropriate parameter values are determined to divide the function into the required degree levels.

The proposed model in the study is designed to be controlled dynamically. The decision maker changes the dimensions of the floating structure according to the results of linguistical degree levels. Thus, while finding optimal parameters, as in the floating architectural design aspect, the aim is to find an optimal decision support model for the preferences of the designers. This study shows how this can be done by using non-linear programming.

Different kind of a parametric system is used with linguistic variables for the required parameters of the proposed model. Varibles are assigned specific degree levels and particular instances are created from a potentially infinite range of possibilities. However in the model, instead of whole shape, dominant parameters of the structural form are considered. By assigning different values to those dominant parameters, even with seven input parameters, different form possibilities can be created. Appropirate equations are used to describe the correlations such as wind force with aerodynamic properties of the form and area of structures. These equations are used as decision support for deciding an associative geometry which are mutually linked to the determined correlations. Furthermore, interdependencies between design possibilites are established and behaviour of the structure under motion-induced loads are clarified. The ability to analyze geometrical relationships correlared with determined forces are taken as a prior design parameter in the proposed model of the study.

Unlike parametric design, application of fuzzy logic not only provides a prodecural process but also an algorithmic description of geometry-force correlation description where Matlab software is used in this algoritmic explorations for conceptual design phase of floating structures. Consequently, a generative process that is determined by numerous varibles is evaluated. Each variable is an interspace into which an external influence can be mapped dynamically. Less concern is given in this thesis to the management of the whole structure itself but more to the regulation of relations of dominant forces, dimensions and eventually the form itself.

Both the application of fuzzy logic as a tool and using expert knowledge as an approach in the conceptual phase, the study tries to change the role of the designer in the desgin process of floating structures.

This study is not focusing on the importance of shape, but the set of principles determined as a series of rule-bases by which specific instances of forms can be generated and evaluated. This can be accepted as a rejection of fixed solutions and as an exploration of infinitely variable potentialities.

The study focuses on the issue of evaluating the architectural form, instead of accepting it as a static construct. The study discusses the characteristic properties of form in floating architecture as conceptually dominat parameter that changes dynamically through the interractions with external and mostly environmental forces. Form, in floating architectural structures, is not only a demostration of internal and parameter driven relational logics, but it also has to respond to dynamic and often variable influences from its environmental space. It is important for any parameter-based design that there are both the external system and the internal information fields are analyzed clearly.

This study asserts, that the proposed model of motion in architecture combines force and motion with form. Dominant wind-wave induced forces, as an initial parameter, affects both motion and form. Consequently, this study, uses the motion and form correlation to evaluate the proposed model with the determined tools and with the support of fuzzy logic.

The case study of this study can be accepted as the application of a model generated with fuzzy logic which uses correlation between motion and form. The rule-based linguistic decision support model uses the kinematics, which is used to study the forces seen in the process of floating structure without considering its mass. Consequently, excluding the mass brings the exclusion of the mooring system. In the proposed model, the dimensions of the floating base and the superstructure geometry are accepted as dominant constraints, allowing designers to create a base understanding of relations that determine the complex behaviour of the model under wind-wave induced motions. The freeboard height is assigned in a changeable or mobile mode, which consequently controls the mooring system, thus provides a system allowing freeboard height change. In floating architectural design process model, freeboard height can be changed under the influence of various site-induced forces, yet all dimensions can be changed in the concept model to get the optimum design requirements of the designer.

Kinematics and issues concerning dynamics are discussed in the proposed rule-based model configuration steps. In contrast to kinematics, the affects of dynamical forces are the focus of the study, especially the forces that do not originate within the system itself. The difficult work of determining the forces of gravity, wind or vortex, collision detection and obstacles deflectors are excluded with the help of experts.

The study discussing the architecture of motion, which is not the same as architecture of movement, formulates linguistically the priorities of form over space by analyzing both the motion and the force at the moment of formal conception. It is the dynamics of forces or force fields as an initial condition that produces motion and the particular transformations of form. The form and its changes become products of the dynamic action of forces. This shift is achieved by the use of fuzzy logic preferences in the study where an acception is realized instead of subjecting generic formal constructs to the influences of force fields. Designers can easily analyze the shape of the degree levels of the force fields with the support of the proposed model of the study by using linguistic fuzzy logic degree levels.

This study opens up a new kind of understanding, where forms undergo variations, giving rise to new possibilities. The determined dominant environmental loads interact with each other within the context of the floating architectural structure. They are connected through a system of interactions, where the whole body is open to variations as new fields of influences are added or new relations are established, creating new possibilities. The surface boundaries of the whole body of floating structure shift or move as fields of influence vary in their location, course of action and direction and most of all, intensity. So, the floating structure begins to operate in a temporally-conditioned dynamic rather than static geography.

The determined parameters with the support of the required tools are converted into a process that leads to varied form possibilities that are generated using a computerized rule-based expert opinion decision support. Where applicable, the digitally-generated form possibilities can be translated directly into a floating structure so that the forces of the creation process are clearly declared in the form of the floating structure.

The correlation of the geometric dimensions of the floating structures to the wind-wave induced motions are discussed with experts. Changes in the dominant dimensions of the form with the applied force fields are essentially subject to physical laws. In the rule-bases of the study, definition of dominant dimensions' importance that prevents the structure from deformations is explained and a linguistic translation of the determined problem within the given spatial context is stated.

The study discusses the wave-wind induced loads and comes to a conclusion; the forces cannot be grasped directly with senses but can only be infered through their effects. However, the application of the model shows that the important thing to be considered is the deformation in the behavioural response of the floating sytem. The perception of the study is the force and its ability to interpret shapes, accepting that deformed forms carry the information about the forces of the origin.

The study is compelling in two significant ways. The first is that the study has an acception that floating architectural design process model evaluation begins with the geometry. The second is that the study tries to raise the issue of correlation of geometry with linguistic fuzzy logic applications, which need further work in architectural design of floating structures.

The application of the concept of floating architectural design shows that architectural comfort targets are mostly challenged by spatial restrictions and compensating such restrictions with conventional means other than fuzzy logic can be extremely difficult.

For future study the focuses should be the computerized tools, artificial intellegence and fuzzy logic adding 3d design tools such as Grasshoper to visualise the determined parameters.

REFERENCES

Akın, O. (2002). Case-Based Instruction Strategies in Architecture, *Elsevier*

Alexander, C. (1979). *The Timeless Way of Building*, Oxford University Press

Aouad, G., Hinks, J., Sheath, D., Cooper, R., Kagioglou, M. (1998). An IT map for a generic design and construction process protocol. *EPSRC IMI Generic Design & Construction Process Protocol* (pg.14).

Arabacioglu, B., **and Arabacioglu, P.** (2008). Application of Fuzzy Logic in Architectural Space Analysize Context, *_BMYS'2008 15-17 Oct* 2008, Eskisehir Osmangazi University (pp. 129).

Antoniades, C. (1992). *Poetics of Architecture: Theory of Design*, John Wiley & Sons, Inc (pp. 181,209,233,248,).

Berkel, B. V., Bos C. (2006). *Un Studio / Design Models Architecture Urbanism Infrastructure* (pp.17,296, 366).

Brawne, M. (2003). *Architectural Thought : The Design Process and the Expectant Eye*, Elsevier, Amsterdam

Bross, I. (1966). *Design For Decision: An Introduction to statistical decision-making*: A Free Press Paperback The Macmillan Company

Brown, D. (2006). Floating Product Systems, Committee V. 2, *16th International Ship and Offshore Structures Congress 20-25 August*, Southampton, UK

Burington, R. (1970). *Handbook of probability and statistics with Tables*, 2nd ed. McGraw-Hill, New York,

Chen, W. (2009). The stability of an oceanic structure with T–S fuzzy models, *Mathematics and Computers in Simulation* 80 (2009) 402-426, Elsevier

Ciftcioglu Ö., Bittermann M.S. (2009). From perceptual towards cognitive robotics in the framework of evolutionary computation. In: Pennacchio, S. (ed.): *Emerging Technologies, Robotics and Control Systems*. *InternationalSAR*, Palermo, Italy

Colwell, J. L. (1989). Human Factors in the Naval Environment: A Review of Motion Sickness and Biodynamic Problems. *DREA Technical Memorandum 89/220*, Dartmouth: Canadian National Defence Research Establishment Atlantic

Cooper, R., Lee, A., Wu, S., Fleming A., and Kagioplu M. (2005). *Process Management in Design and Constrcution*, Blackwell Publishing,

Cross, N. (1984). *Developments in Design Methodology*, Wiley, (pp. 9,123,175).

Crossland, P. (1994). Experiments to Quantify the Effects of Ship Motions on Crew Task Performance- *Phase II: Assesment of Cognitive Performance* DRA/AW/AWH/TR94001

Dasgubpta, S. (1994). *Creativity and Invention and Design: computational and cognitive explorations of technological originality*, Cambridge, Cambridge University Press

Dreiseitl, H., and Grau, D. (2009). *New Waterspaces*, Birkhäuser

Dubois, D. (2009). A Unified View of Uncertainty Theories- *Fuzzy Systems Association World Congress and 2009 European Society for Fuzzy Logic and Technology Confrence* (IFSA-EUSFLAT 2009)

Eastman, M., C. (1999). *Building product models: computer environments supporting design and construction*, Boca Raton, Fla.: CRC Press,

Eastman, M., C., McCracken M, W. (2001). *Design knowing and learning: cognition in design education,* Amsterdam, *Elsevier*

Ercoskun, K. (2006). *Linking customer relationship management and architecture / engineering / construction processes through facility management integrationdesign process improvement*, Ph.D, ITU

Eugene, H. (1987). *Optics, 2nd Edition,* Addison-Wesley

Fajardo, J. (2009). *Hi-tec Architecture*, Cologne, New York: Daab, (pp. 242,278,310,334,370).

Flachbart, G., and Weibel P. (2005). *Disappearing Architecture, From Real to Virtual to Quantum*, Birkhuser – Publishers of Architecture Basel-Boston- Berlin (pp. 61).

Fousert, M.W. (2006). *Floating Breakwater A Theoretical study of a dynamic wave attenuating syste.* MSc, TU Delft (pp.19,20,26,50,52).

Fry, T. (2009). *Design Futuring / Sustainability, Ethics & New Practice*, Berg, Oxford New York (pp. 29,125,145).

Fuller, B. (1981). *Fuller Critical Path*, St Martins Press (pp. 332).

Fisher, A. (1993). *Small Group Decision Making: Communication and the Group Process*

Gay, Ln. (1954). Labyrinthine factors in motion sickness. *Int Rec Med Gen Pract Clin. 1954 Dec;167(12):628-30*

Goulthorpe, M. (2008). *Possibility of (an) Architecture*, *Collected Essays*, dECOi Architects, Routledge

Graaf, R., E. (2009). *Innovations in Urban Water Management, Feasibility Case Studies and Governance*, Ph.D, Delft Technique University

Griffin, M., Lewis, C. (2009). 'Motions and crew responses on an offshore oil production and storage vessel', *Applied Ergonomics* 40 (2009) 904–914, Elsevier

Heller, S. (2008). *Designing Disasters Great Designers, Fabolous Failures, Lessons Learned'*, Allworth Press/Newyork,

Hughes, S. (1993). *Physıcal Models and Laboratory Techniques in Coastal Engineering***,** Singapore : World Scientific

Ichida, T. (1996). *Product Design Review, A Method for error-free Product Development*, Press Portland, Oregon

Johnson J., Alexiou, K., Zamenopoulos, T. (2010). *Embracing Complexity in Design*, Routledge, Taylor&Francis Group, London and New York, (pp,73,85,95,177,189,182-186,179)

Jones, C. J. (1980). *Design Methods: Seeds of Human Futures*, New York: John Wiley and Sons.

Kahraman, C., and Çebi, S. (2010). Indicator design for passenger car using fuzzy axiomatic design principles, *Expert Systems with Applications* **37** (2010) 6470–6481

Kalay, Y. E. (2004). *Architecture's New Media Principles, Theories, and Methods of Computer Aided Design*, The MIT Press, Massachuseetts London, England

Kalay,Y. E. (1992). *Principles of Computer-Aided Design: Evaluating and Predicting Design Performance*, Wiley-Interscience Publication, John Wiley &Sons, INC.

Kaymak, U., and Sousa, J. M. C. (2002). *Fuzzy Decision Making in Modelling and Control'*, World Scientific

Knauer, R. (2008). *Basic Principles and Methodody of Design*, Birkhauser,

Kocak, G. (2008). *Ergonomic Analyses in Ship Management*, MSc, Istanbul Technical University

Kolarevic, G. (2008). *Manufacturing material effects : rethinking design and making in architecture* London : Routledge, 2008

Kronenburg, R. (2007). *Flexible 'Architecture that respond to change'*, Laurence King, (pp.11,6,7,11-19,34-35,42-43,44-45,105-107,174-175,208-231).

Koivo, H. N. (2006). *Fuzzy Systems: Basics using Matlab Fuzzy Toolbox.*

Kumar R., (1999). *Research Methodology*, Sage, (pp. 17,8)

Leeuwen J., Timmermans H. (2004). Recent advances in design and decision support systems in architecture and urban planning, *International Conference on Design & Decision Support Systems in Architecture and Urban Planning* (7th:2004: Sint-Michielsgestel, The Netherlands)

Lidwell, W., Holden, K., and Butler, J. (2010). *Universal Principles of Design*, Rockport

Lane, D. (2009). *Complexity Perspectives in Innovation and Social Change*, Springer

Lawson, B. (2006). *How designers think : the design process demystified*, Amsterdam : Elsevier; Oxford : Architectural Press

Lynn, G. (2010). *High Performance Architecture*, Yale School of Architecture

Maslow, A. (1943). A Theory of Human Motivation, *Psychological Review, 50, 370-396*

Miller, S. (1995). *Design process: a primer for architectural and interior designers*, New York: John Wiley

Magrab, B. E. (2010). *Integrated Product and Process Design and Development: the product realisation process*; CRC Press, (pp. 7, 31)

Medasani, S., Kim, J., Krishnapuram, R. (1998). 'An overview of membership function generation techniques for pattern recognition.' *International Journal of Approximate Reasoning*,**19**,391- 417

Mileta M. T., and Shaoping W. (2009). Product Realisation: a comprehensive product approach, I*nternational Conference on Comprehensive Product Realization* (2007: Beijing) (pp. 196).

Moma, P., (2008). *Design and the Elastic Mind,* The Museum of Modern art, New York (pp. 139)

MacGrath, B. (2008). *Digital Modeling for Urban Design*

Olthus, K., and Keuning, D. (2010). *AFLOAT Building on Water to Combat Urban Congestion and Climate Change*, Frame

Oosterhuis, K. (2002). *Programmable Architecture*, L'ARCAEDIZIONI

Patil, S.G., Mandal, Hegde A.V., Alavandar, S. (2010). Neuro-fuzzy based approach for wave transmission prediction of horizontally interlaced multi layer moored floating pipe breakwater, *Ocean Engineering*

Pethybridge, R. J. (1982). Sea Sickness Incidence in Royal Navy Ships. *INM Report 37/82, Institute of Naval Medicine,* Gosport, England

Poincare, H. (2000). *Science and Method*, Introduction by Andrew Pyle, South Bend, Ind., St. Augustine's Press,

Powell, W. R., Crossland, P. (1998). A Literature Review of the Effects of Vessel Motion on Human Performance- *Possible Implications for the Safety and Performance of Personnel Abroad Floating Storage and Off-Loading Vessels INM Technical Report* No.98027

Prominski, M. (2012). *River. Space. Design, Planning Strategies, Methods and Projects for Urban Streams,* Birkhauser Verlag AG

Rakheja, S., Dong, R., and Patra, S. (2010). Biodynamics of the human body under whole-body vibration, *International Journal of Industrial Ergonomics **40** (2010) 710e732*

Ribbens, J., (2000). *Simultaneous Engineering for New Product Development: manufacturing applications*, Wiley (pp. 25726282)

Rijcken, T., (2006). Floating Neighbourhoods as they were and will be; why dwellers would want to live on water, *'Doing, thinking, feeling home'' 14-15 October – Delft*, The Netherlands

Sariyildiz, S., Bittermann M. S., and Ciftcioglu, **O**. (2008). Multi-objective Optimization in the Construction Industry, *The 5th International Conference on Innovation in Architecture*, Engineering and Construction, AEC2008

Sariyildiz, S., Bittermann M. S., and Ciftcioglu, O. (2007). Building Performance Analysis Supported by GA, IEEE *Conference on Evolutionary Computation (CEC) 2007*

Satır O., Berberoğlu S. (2010). Estimating Urban Green Cover Using Fuzzy (Soft) Land Use Classification Techniques and Ancillary Data

Sivanandam, S. N., Sumathi, S., Deepa, S. N. (2007). Introductio to Fuzzy Logic using MATLAB, Springer

Standard Canada. (2001). Standards for Float Homes and Live-Aboard Vesselsin Victoria Harbour, Transport Canada Issued by Order of the Port of Victoria Harbour Master, November 1, 2001

Stevens, A. D. And Parsons, M. G. (2002). Effects of Motion at Sea on Crew Performance, *Marine Technology*, **Vol 39** (1) (pp. 29-47).

Steinitz, C. (1990). A Framework for Theory Applicable to the Education of Landscape Architects and Other Environmental Design Proffesionals, *Landscape Journal, **Vol. 9***, No 2.

Sen Z., Öztopal A.,Topçu B. (2008). Modern Methods in Science Symposium,: *BMYS'2008, 15-17 10 2008*, ESOGU, ITU (BUMAT)

Sen Z. (2010). *Fuzzy logic and hydrological modeling*, Boca Raton : CRC Press

Unwin S. (1997). *Analyzing Architecture*, London, New York : Routledge

Warszawski, A. (1999). *Industrialized and Automated Building Systems,A Managerial Approach*, E&FN SPON (an imprint of Ruthledge)

Watanabe, E., Maruyama, T. (2000). Design and construction of a floating swing bridge in Osaka, *Marine Structures **13** (2000) 437-458, Elsevier Science Ltd.*

Weinstock, M. (2010). *The architecture of emergence: the evolution of form in nature and civilization*, Chichester, U.K. Wiley, (pp. 42,79,163).

Wertheim, A. H., Kistemaker, J. A. (1997) Task Performance during Simulated Ship, *Movements Report TM-97–A014*, TNO Human Factors Research Institute, Soesterberg, Netherlands

Wu, Y., Cui, W., and Zhou, G. (2001). Innovation in Ship Production Hull Structure Superstructure Practical Design of Ships and other Floating Structures, *International Symposium on Practical Design of Ships and Other Floating Structures (8th : 2001 : Shanghai, China), Amsterdam, New York: Elsevier,* (pp. 359)

Wu, Y., Cui, W., and Zhou, G. (2001). New Production System for Vessels of Composite Materials using Adjustable Mould, *International Symposium on Practical Design of Ships and Other Floating Structures (8th : 2001 : Shanghai, China), Amsterdam, New York: Elsevier* (pp. 367).

Zadeh, L. (2009). Openning Message- *International Fuzzy Systems Association World Congress and 2009 European Society for Fuzzy Logic and Technology Conference (IFSA-EUSFLAT 2009)*

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