Flood-proof houses for the future:
A compendium of design

In association with

RIBA
As climate change takes hold, most scientists and meteorologists are agreed that we are more likely to see milder, wetter weather, resulting in flooding – like that experienced in 2007 – becoming a more regular occurrence.

At the same time, the Government have also set out plans to build three million new homes by 2020. As brownfield land in the UK is already limited, it is likely that some of these properties will be built on flood plains. Insurers want to continue to provide insurance to as many people as possible – but assurances are needed that these houses will be designed with flood risk in mind.

Sir Michael Pitt, in his final report to Government assessing the floods of 2007, identified that people and homes need to be better prepared for flooding, and that we need a much more innovative approach to designing and preparing for flooding.

Designing for flood risk is an issue that many architects are aware of when considering where and how to build houses, but whilst this is being considered and developed, no one has yet presented a range of solutions to this problem.

This competition was launched to encourage a more innovative set of solutions that can balance development needs with environmental change. Architects were asked to design a house for the future, which could be built on a flood plain, and took the associated flood risk into account via its architectural features and design. Overall, we sought designs that would help ensure that properties built on flood plains are designed to mitigate the flood risk, are workable, and, of course, insurable.

This compendium of design ideas showcases some of the entries received. Each design featured is accompanied by a comment from the architect, explaining how the house would be protected in the event of a flood.

Having received over 80 entries, the Jury Panel assigned to judge the competition met on two occasions to decide on the overall winners. When it came to the final judging, we were unable to choose one overall winner, so we decided to choose four winners, all of whom explored very different solutions of how to protect houses against flooding. Further detail explaining the rationale behind our choice of winners is included in the Chairman’s Report on page 4.

Further information on the competition, including the full design brief, can be found via the accompanying website: www.floodecstormdesigncompetition.co.uk

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1 As outlined in the Housing Green Paper – Homes for the future: more affordable, more sustainable, published by the Department for Communities and Local Government, July 2007
Flooding now presents a major risk to the UK. The floods of Summer 2007 proved just how devastating flooding can be, with thousands of families and businesses out of their homes or unable to trade, and the cost to the insurance industry alone standing at approximately £3 billion.

We all have a role to play in managing and reducing this risk. As the UK’s largest insurer, we work hard to keep flooding at the top of the political agenda, campaigning for a long term strategy and clear direction for flood management. Both are essential for the delivery of a successful UK flood management policy for the benefit of our customers and to enable us to keep insurance affordable.

We also need to be realistic. Flooding is a fact of modern life - we need to accept and learn to live with this but importantly we also need to make sure we are adequately prepared. This competition has been designed to help achieve that aim.

At Norwich Union, we believe that homes and businesses should be built in areas away from flood risk. However, we recognise that in some cases this may not be possible for a variety of reasons, so we sponsored this competition to encourage architects to design properties that could better cope with the threat of flooding.

The following designs present new and exciting solutions to living with the risks of flooding. Some of them build upon existing solutions, others present brand new ideas, and some of the entrants have examined what works overseas to inform their design concepts.

We have had a tremendous response to the competition and were unable to include every entry in this brochure. However, the designs included on the following pages reflect the creativity that we saw from all participants, and I would like to thank each and every architect for taking the time to submit their entries.

This competition has been very exciting to be involved in, and I urge all those with an interest in flood risk management to work together to create a long term, sustainable approach to address the growing risks. My hope is that this competition creates new ways of thinking to enable us all to better achieve this.

Igal Mayer
Chief Executive Officer, Norwich Union Insurance

It has been fascinating and instructive for the RIBA together with Norwich Union to explore how design-led solutions can respond to the flooding challenge. As climate change begins to bite, the expected effects – rising sea levels and more extreme weather patterns – make the need for a co-ordinated response all the more urgent. At the same time the pressure for new housing, and our desire to live close to water, makes it likely that there will be more new development at risk of flooding.

Reducing the risk of flooding does not begin and end with concrete walls and buildings on stilts as the results of this competition show. Good design lies at the heart of creating communities that are more resilient against flooding, of lessening the cost caused by flooding when it does occur, and of minimising the impact flooding has on local livelihoods and safety. The variety of the approaches demonstrated by the entrants shows the enormous potential of such design.

Sunand Prasad, RIBA President

As estimated by the Association of British Insurers
Chairman’s Report

The competition received a tremendous response with 85 entries received, all of an extremely high standard of presentation. I know from experience that an enormous amount of time and effort goes into preparing any competition submission. However, when one considers that the challenge of flood risk is one that the profession is still in the early stages of getting to grips with, it is clear that the entrants in this case have also invested significant effort in researching and understanding the issues.

The proposals generally fit into one of four broad strategic approaches to designing for flood risk: raising the level of accommodation above the design flood level; floating or amphibious designs; resistant proposals; and resilient design schemes. Perhaps the most exciting thing to come out of the competition has been the fantastically diverse range of ways in which these strategies have been applied and integrated into overall housing designs. This is where the value of intelligent and inventive design can really be seen in bringing together often conflicting requirements and attempting to resolve them to arrive at a holistic solution.

In the end the judges could not identify any single entry as an overall winner. There were a number of reasons for this the first of which was perhaps the inherent difficulty of designing for a generic site at risk of flooding. Entrants would have probably found it easier to design for a particular site with a set of specific characteristics. Judges would also have in all likelihood found it easier to assess how well proposals satisfied the site’s challenges. However had this been the case much of the diversity of submissions would have been lost.

Secondly the judges felt that no one design completely fulfilled all of the brief criteria which highlights just how challenging it is to reconcile designing for flood risk with the full range of contemporary design standards and create a good quality design. In particular, mitigating flood risk whilst providing equal access (life time homes), safety and security (Secured by Design) and economically viable development proved to be a challenge.

Finally, none of the four mitigation approaches are universally applicable or entirely sufficient on their own. And whilst a number of entries illustrated – with innovative and excellent design proposals - how one of the approaches could be applied none of them satisfactorily combined more than one together.

A clear lesson that emerges from the competition is the need for a combination of mitigation strategies including raising levels, resistant construction, resilient designs and emergency planning in order to provide the best level of protection across a range of flooding scenarios.

The competition comes in advance of new Building Regulations promised to cover development of resistant and resilient properties in areas at risk of flooding. It also comes in advance of new mapping from the Environment Agency for areas at risk of surface water flooding. The approaches that the competition illustrates through developed design proposals will I hope provide a valuable insight to those developing these new regulations as to just how broad a range of inventive strategies are available.

This publication represents and excellent compendium of design strategies that seek to mitigate flood risk and will be useful reference to anyone involved with the issue.

Finally Norwich Union is to be congratulated for their foresight and willingness to positively engage with the issue by instigating and sponsoring the competition.

Kiran Curtis
Principle, KCA Architects
About Norwich Union
Norwich Union is part of the Aviva Group and is the UK’s largest general insurer with a market share of around 15 per cent, with a focus on insurance for individuals and small businesses. Norwich Union products are available through a variety of distribution channels including brokers, corporate partners, such as banks and building societies, and Norwich Union Direct.

Norwich Union have consistently campaigned on flood defence and resilience issues. Over the past few years we have: launched the UK’s first flood resilient home in Lowestoft, Suffolk; developed our own unique flood map, giving us the ability to map fluvial flood risk on a more accurate basis; and launched www.floodsim.com - a website that uses an online simulation game to explore flood policy decisions, and the important choices that need to be taken.

Our work with the Royal Institute of British Architects (RIBA) is intended to bring a new dimension to the debate on how we can adapt our way of life and future building plans in the light of an increased flood risk.

About the RIBA
The Royal Institute of British Architects (RIBA) is the UK body for architecture and the architecture profession. It provides support for 40,500 members worldwide in the form of training, technical services, publications and events, and sets standards for the education of architects, both in the UK and overseas.

The RIBA is constantly seeking to promote excellence in architectural design. Architectural competitions have for many years been recognised as one of the means of achieving that aim. They are the vehicles for the release of creativity, vitality, new talent and new ideas. The RIBA Competitions Office organises bespoke architectural competitions that encourage excellence in design and are run smoothly from inception through to a winner being chosen. The Office has vast experience of managing competitions for a diverse range of clients, project types and budgets.

For more information on the RIBA’s work combating climate change, and for a copy of the RIBA’s guide to Designing for Flood Risk, visit www.architecture.com/climatechange
In reading the remarkable stories of those living through floods from across the country it became immediately apparent that the design for a flood proof house would have to work harder than simply providing durable finishes at flood level. Articles from the BBC describe accounts of elderly not wishing to leave the familiarity of their home, of people stranded alone for days, and of the simple frustration of not being able to take their dog for a walk. The house, therefore, in addition to protecting its occupants from the dangers of flooding, would also have to cater to occupant’s individual needs to minimise disruption.

On a positive note, living through a flood, it seems, binds local communities tighter together in their plight to survive tragedy. The stories of bravery and support are equal in number to those of misfortune and it was important that the flood house tap into, and promote, this incredible community support network.

The 3 design principles for The Turnaround House are:
1. Creating an adaptable house that responds to a flood, without compromising living during the rest of the year.
2. Ensuring that occupants’ needs are met at all times.
3. Acting as a physical link to the community and its support networks.

An Adaptable House:

For most of the year the flood house functions as a typical house and only in a flood does it transform and a ‘turned around’ living arrangement is adopted. When a flood warning is issued, occupants relocate upstairs while water is allowed to penetrate the ground floor. A robust concrete dado extending from the foundations allows easy cleaning after the flood subsides. Drinking water is concealed in a deep flood void and storage walls can be tuned around to access emergency supplies or relocated.
to act as privacy dividers. The timber shutter at the first floor folds down to become the new front entrance, complete with bin store.

**Tailored Living:**

Provisions are made to tailor to each family member’s needs, right down to those of the pets and car. The typical arrangement of bedrooms upstairs, living downstairs is inverted to raise the family’s most expensive belongings away from damage by flood waters. Desks in the storage wall provide office space in case occupants cannot get to work or school. A sunken concrete pontoon allows for the family car to be floated out of harms way. A small green space is provided for pets when the garden is flooded. Gabion walls act as a filter to limit the amount of debris entering the garden where children and pets play.

**Community Links:**

Timber shutters provide security to the first floor and fold down like drawbridges to join neighbouring balconies in a flood, thereby creating a continuous raised walkway that replaces the flooded pavement below to reconnect the community. The elderly are no longer isolated alone, children can visit their friends, neighbours can easily help, and provisions can be safely accessed. It is envisioned that these raised pavements could link to local amenities such as shops, community centers and raised playgrounds.
Judges' comment

A good masterplanning-led scheme based on an integrated approach to managing water at the building, street and development levels. The judges thought this was a good pragmatic approach incorporating resistance for low level frequent floods and more major floods without too much disruption to the community. The scheme includes some lovely green open spaces designed to store and direct flood water away from properties and, given the right site this was considered to be a very replicable and commercially viable scheme. The key weakness was the issue of access for cars and services however it was felt that with some adaptation this could be achieved into a workable solution.
The close relationship between land development, drainage management and housing design is significant in our design approach to flood resistant housing. The design of houses in relation to their private open spaces, the street, the neighbourhood and overall masterplan are interrelated in minimising the damaging effects of flooding.

Our housing masterplan revolves around Sustainable Urban Drainage Systems (SUDS) which endeavour to mimic the natural movement of water from a development, thus reducing the risk of floods to houses. Instead of streets with cars, permeable surfaces and swales are designed along the front of houses which are connected to nearby basins and retention ponds. They work as a system to retain storm water and runoffs from hard surfaces. The removal of the street also means that the large swathe of paved and green space in front of houses can potentially become a valuable social space for the community.

The proposed flood resistant single family dwellings are based on the terrace house typology, arranged back-to-back. This arrangement allows the creation of a raised public footpath at first floor level along the rear of the houses. During a flood, it becomes a safe access route for victims and emergency relief teams. Courtyards are inserted into each house to bring light and air to the rear ground floor living spaces, which will otherwise become inhabitable due to the back-to-back arrangement. Each courtyard will be landscaped and its porous surfaces are effective in reducing the quantity of surface water run-off. To further reduce the rate of run-off, roof gardens and rain-water harvesting systems are introduced to each house.

The ground floor levels of each house are split by cut and fill of the site. The front half has a level 300mm whereas the rear half is at 1200mm above ground. This means that only half the ground floor of the house will be submerged in water during a major flood. The houses are designed to resist entry of flood water at levels below 300mm, but for higher levels, a water entry approach is adopted. This strategy gives time to occupants to move their belongings to a higher ground before the water actually enters the house. The kitchen – a space with the highest number of electrical appliances – is located on the higher ground level at the rear.

The construction of each house needs slight modifications of standard practice. For example, raised door thresholds prevent low water entry and engineering brick foundation walls are used for their proven ability to prevent water ingress compared to other types of masonry wall. For the water entry strategy, the resilience of materials and their locations are of prime importance. For example, ceramic tiles floor finishes will be used and insulation is the ‘closed-cell board type’, fixed above the ground floor slab and on the internal faces of the external walls. While these boards are moisture resistant to a certain extent, their location facilitates easy replacement if damaged by prolonged floods.
Joint winner No.3:
From the outset, the scheme was conceived upon the vision of creating a place where is safe, accessible, flood resilient and leading the way in sustainable design. To achieve this, the scheme seeks to adopt a holistic approach to tackle the challenge of mitigating the flood risk and to restore the balance for the community and its ecology.

Both the house and the masterplan are set to exceed the targets set for energy efficiency in building design, construction and maintenance. The scheme will optimise land use, balancing the building foot print and green spaces and creating a density that will support biodiversity and preserving the ecological value. The scheme will be designed to incorporate an integrated water management system which to include bio remediation and infiltration opportunities within the streetscape in the form of planted swales and attenuation features. ‘Green zone’ will be used as the key element to maintain the strategy. There will be pedestrian path, cycle route, water feature, attenuation features and planted swales, creating a visual amenity that will enhance its biodiversity.

The concept for the house is a simple, modest and austere living box related strongly with its landscape. The house is made of white finished concrete, clear glass with veil of vertical timber fins. The timber skinned glass box which house the living spaces, sits on its concrete base, which is not only act as the flood defence, it extends to form the landscape elements.

Externally, the varied densities of vertical timber fins are to provide solar control and gives different degree of privacy to the different types of spaces related to the type of activity. The house has two distinct contrasting elements, the concrete, which is the solid element, recessed from the front to provide main entrance and extending along the long axis to form landscape walls with facilities that can be accessed externally. The timber box is exactly the opposite; it is lightweight and has variable transparency, offering maximum contact with nature and views. The rich timber skin, respond to the changing quality of natural light, making the living spaces behind it sensory contact with nature and the changing seasons.

To guarantee the legacy of this scheme, the ‘Green Zone’ will be built to last and designed to maintain the vision. The network of SUDS system is similarly designed to be both robust and flexible, and allow for the masterplan to stand the test of time.

Judges’ comment
This scheme includes some lovely features and overall is a simple and economic concept. This was a good example of a house designed with the premise that water will not enter – and successfully seemed to achieve a resilient construction that is also attractive. More thought would be needed regarding access and egress in times of flood but overall this was a well integrated, thoughtful, relatively inexpensive and practical solution.
Judges’ comment

A well researched proposal based on an amphibious house using a concrete hull with prefabricated living pods. The judges thought this was a very clever idea with some great features, and especially liked the nautical references. The proposal would be reliant upon an access road raised to first floor level and so might be more suitable to a sloping or waterfront site. However the key concern related to the issue of flow of water on fluvial floodplains, where its depth and velocity means it usually carries moving debris within it. A consequence of this could be that trapped debris underneath the house could have an impact on its foundations, resulting in structural stress. Unfortunately this important detail hadn’t been fully thought through. Also the construction of the modular parts needed further consideration. Overall though the judges praised this as a great looking, stylish and potentially workable interpretation of a floating solution.
There is nothing new or revolutionary about floating architecture. The theory is sound, the technology exists and it has been proven in numerous precedents around the world.

This design however is concerned primarily with successful architecture, not just successful engineering. It is first and foremost a contemporary family home – that it can withstand the effects of flooding has influenced key design decisions and shaped its aesthetic to a degree but has never compromised the achievement of a successful living environment.

The house can be described in three discrete sections; a site-specific hull element and two prefabricated elements for sleeping and living. Nautical industry has inspired the floating technology and engineering but this philosophy has also permeated beyond the practical demands into the architecture of the spaces and the aesthetic palette.

The hull element is a watertight concrete box that is cast in situ; the only real restriction on its design is that it is capable of taking the first prefabricated element. This is a modular steel frame that contains the sleeping areas and is partially sunk into the hull. The living spaces are accommodated in the second prefabricated element, a wedge shaped box that is stacked on top of the first prefab and cantilevers over it at either end. Clad in weathered zinc, the resultant form has a deliberate shipping container aesthetic.

Flotation is achieved through basic principles of displacement. With the hull resting on pile foundations in normal conditions, the house will remain in situ as flood levels rise, eventually becoming buoyant at a critical height. To the rear of the house, extended piles form columns, which are attached to the hull via steel collars. This allows vertical movement with the rising and falling water but prevents lateral drifting.

The Amphibious House allows for a contemporary lifestyle within its modern living spaces. The continuing inspiration of shipping container aesthetic and nautical industry is evident throughout the interior – most notably in a series of large sliding panels on that regulate access, views, shading and privacy. For example mesh panels over the large glazed areas can be adjusted accordingly, as can sliding wall panels between the interior and exterior. By utilising these large gestures a flexible environment is created and the fundamental experience and orientation of the spaces can be easily altered.

If building on flood plains is inevitable, much better to accept the occurrence of fluctuating water levels and design homes that can actively assimilate to alternative scenarios. A static solution can never satisfactorily address a problem that is constantly changing. The Amphibious House is the antithesis of these static solutions: it is a dynamic response to a dynamic problem.
This proposal for a flood proof house of the future is an accessible and adaptable model for detached family home. The safety of the occupants during a flood is paramount, but it is also vital that the house is a pleasant place to live, both when compromised by flooding and under normal circumstances.

In visual and massing terms the motivation for the design is that it should be understandable, in a legible and attractive domestic idiom. The domesticity of the design remains important despite the unconventional demands of the context within which it would be sited.

In order for the design to be relevant to both the UK house building and insurance industries it must be achievable using standard construction techniques and not rely on novel or untested methods. This is also vital with regard to future adaptation by the owners – it is a natural requirement for detached and semi detached housing of this nature that it can be adapted and modified in the future.

Those aspects of the design that directly address the flood risk are based on common sense approaches to geometry and material. There is a fundamental desire to ensure that the house will remain fully operable [and hopefully a delightful place to live] even in the event that the ground floor and garden are submerged.

There are two modes with regard to the protection of the house from flooding. The first is simply to install drop in shutters at the front, back and utility room entrances. These shutters slot vertically into precast concrete channels immediately in front of the doors. Similarly the garage doors are inclined outwards [similar to a canal lock] such that the water pressure pushes them to a seal.

If these shutters fail, or are not installed in good time then the assumption must be that the ground floor level of the house will likely flood. To cover this eventuality the design has a number of features designed with this situation in mind.

Highly commended:
Moxon Architects Ltd

Judges’ comment

A resilient approach and a lovely design which responds to the risk with well thought through sacrificial areas. The judges thought this was a sophisticated and extremely well presented design. However there were concerns over how well the mitigation proposals were integrated with the design concept particularly the issue of getting water out. There were also weaknesses in the effectiveness of the system of resistant doors and shutters proposed. More thought could also have been given to access and egress in times of flood.
Our proposal anticipates that, at times of flooding, the houses become the flood defence line.

Using traditional but robust building materials which allow the building to be resilient to flood water raising against the external walls, we have made one significant amendment to the traditional details which is to reverse the front door from a 'French casement' frame. Opening outwards the door is set on drop hinges to self-close and will in the event of flooding be pressed against the door frame sealing out the flood water.

"No Man is an Island" – John Donne

Flooding in residential areas typically has an isolating effect on families and individuals, stranding them on small islands- their homes. This proposal strives to resolve that problem by approaching it first from the scale of the community, in which flooding is both mitigated and utilized as a means of linking homes together, sustaining community in perhaps its greatest time of need. By approaching the design from the broader point of development, we can more easily reduce the impact of flooding on individuals and their property. We can also promote a holistic, functional and beautiful community, whether floodwaters are present or not. A common floating “boardwalk,” which connects the homes to one another, rises and falls with floodwaters and acts as the spine to which the houses connect. The boardwalk creates a constant circulation network and serves as both a literal and symbolic expression of what people require in a time of crisis- access to one another. A raised foundation, shared by two buildings, creates a protected area above the prescribed flood level, on which vehicles and gardens are protected from floodwaters. Environmentally responsible design features at each two-unit house serve both to reduce the development's environmental impact and to allow each house to sustain vital functions for its occupants during flood events. Empowering individuals allows neighbours to fight the effects of a flood together by sharing support and resources, strengthening and sustaining the sense of community.
Design objectives

This proposal proposes a cut and mound approach to the flood plain. The inspiration has come from ancient building techniques, and the natural phenomena of drainage patterns on moors and tidal flats. The development diverts the flooding away from the town that has spawned it.

The flooding is the flavour and character of the place. We are interested in celebrating this liquid plain in the same way that one might celebrate the first fall of snow. We have sought to make a lively and opportunistic environment with which to seat the development.

The house itself is economic and modest in approach. It is basic in proportion, repetitive in its construction and relies on a proven spatial configuration to be an effective environmental and flexible model. It takes the common wisdom of traditional Chinese and early Christian monastic architecture and references Jorn Utzon and Richard LePlastrier's courtyard buildings.

We have presented a flexible, passive solar house, which can be tailored to a site and occupant. The courtyard begins with building a perimeter wall to the boundary, with a wide aperture to the south, to create a private warm microclimate. Depending on the occupant's needs, one is free to build off the four walls. Depending on the site orientation, different roof forms can be rigged to protect and capture the elements into the house.

In regards to our vision for the future, it is equally the notion of sameness and difference that the future may hold that is of interest to us.

The intention is to incorporate a series of staged strategies to firstly prevent floodwater entering the house, but if this still occurs, to then minimise the damage done by the flood and to allow the occupants to continue to inhabit their houses with the minimum amount of disruption.

As a first line of defence, the layout proposes urban blocks with narrow house frontages to minimise exposure to floodwater. A shutter is provided by these entrances, to prevent the water entering the building.

To minimise damage, the house types are designed so that the living areas with the most valuable and vulnerable equipment and belongings are on the upper floor, while the bedrooms and bathrooms are at ground level and are constructed in pre-cast concrete with a tiled finish, which can be simply hosed down. Soft furnishing at this level will be on raised plinths.

The upper storeys are of conventional timber frame construction.

Externally, a planted terrace above the garage provides a garden which will be unaffected by the floodwater, and an external concrete staircase provides access to this and to the house when the area is flooded. There is also a raised garden at the rear. A floating hardstanding, constructed from marine ply and polystyrene, is located at the front of the houses, which will allow a vehicle to float above the water level to escape flood damage, and a similar floating deck for pot plants etc is also positioned by the entrances.
The house as a community unit

The cohesion and security found in a strong community can affect the socio-economic and physical well-being of its members. This cohesion is particularly evident in times of crisis or hardship. The term ‘community’ can be interpreted both socially (bonded group) and morphologically (physical proximity).

We propose a model which is the physical embodiment of the community: this is the “terp” or inhabited mound.

The design proposes the combination of both the built dwelling and the landscape within which it is situated: their combined potential can offer a comprehensive solution to flood prevention and protection. The strategy involves the creation of a basic integrated dwelling unit. This consists of dwellings, green and garden spaces, combined water management systems and energy supply.

The first act in making the house is to shape the landscape; the excavation and movement of ground creates a hollowed void and a raised archetypal mound. Underground water storage tanks are placed in the void. Street level remains at the existing ground level. The houses are clustered to form a community with a common reliance on interconnected mounds, shared sunken water storage and collective energy resources. The different cluster models (terraced, courtyard and suburb) offer flexibility in the organisation, form and design of individual houses; this enables variation in housing mix and encourages place-specific housing design.

The house has a split-level ground floor, located on the transition between the mound and street level. The lower level adjoins the communal area and the upper level looks out upon the garden and the landscape beyond. The entrance and stair are situated between these levels in a sealable core. The concentration of the services and load-bearing structure in the core and first floor allow freedom in the construction and organisation of the upper levels of the house.

Stephen George & Partners

Essentially the concept can be best described as a hydraulic ‘lift’ system, allowing part of the structure most in danger to move only vertically by utilising the natural buoyancy of the flood water as the potential lifting mechanism. The idea of floating technology is used extensively in the Netherlands, though these solutions float the entire structure and can make habitation during a flood hazardous due to significant movement in the structure. Static solutions mitigate this scenario but make the home less accessible and can be at odds with the original architectural character of a neighbourhood.

The design combines the benefits of floating and static solutions in a single dwelling. The lightweight ground floor accommodation is to be constructed on a raft foundation system that can float when immersed in flood water. In turn the structure is guided on vertical runners that resist potential horizontal bending moments caused by the flow of flood water.

The second floor accommodation shall be static and rigidly secured by support columns with deeper foundations. The upper floor/s will provide the essential living quarters, habitable during a flood. A minimum flood threshold zone between ground and first floor is introduced to allow the rising floor level beneath and is made weather tight by a proposed flexible and collapsible system. In addition all services and drainage enter within the static column supports that double up as the vertical guide runners for the ground floor ensuring rotational stability.

Due to the potential variation in floor to floor heights, a unique staircase with a pivoted stringer bar that can alter the pitch and riser height would be employed.
QAD Architects

QAD Architects’ intention is to take a commercially balanced view of minimising the damage and possibility of flooding. We felt that if the project was to be realisable the best approach would be to develop the proposals alongside the prime movers of the residential industry, they being a national volume house builder, in addition to a quantity surveyor and a civil engineer. It is with their endorsement that we believe this vision could be made a practical reality.

The proposed plot size is optimised in order to achieve higher density and less land take, thereby encouraging water seepage with the reduction of impermeable surfaces as a proportion of the site. This strategy enables a gain of 10 additional units on a 1ha site including infrastructure. Rooms have been arranged to ensure that overlooking and privacy is not compromised as a result of the reduced plot length and building footprint.

Using traditional construction materials, the building sits on an impervious concrete tanked base providing both a water barrier and structural stability against the rising water pressure. Rooms are strategically relocated to ensure continuous habitation and minimise damage. A grass ramp from the drive caters for the car to be parked temporarily at the elevated rear garden to avoid damage during flooding.

Through cut and fill a portion of the rear garden is taken to form a sunken communal green space, intended to create an area of attenuation/balancing. This serves to both instil a sense of a community and provide elevation to the private gardens.

Stanton Andrews Ltd

At a design flood depth of 600mm the water is at a depth whereby the risk of structural damage becomes significant. The strategy adopted starts from the site layout, whilst the site may be flat, the creation of swales 2m deep and 5m wide throughout the site can allow the creation of accommodation ‘islands’ which maintains the flood storage capacity and also provides the fill to allow the gardens to be raised. They also provide ecological benefits as ‘wild-life corridors’.

The accommodation on the ‘islands’ is arranged over three split level floors, the top floor is within the loft with the timber upper floors cantilevering over the masonry ground floor base. This reduces the building footprint ensuring that land and material use is optimised. The house has 4 bedrooms, two bathrooms, a lounge, kitchen/diner, single car garage and an entrance level wc.

The ground floor accommodation is split-level, at low level is a garage with robust finishes which is allowed to flood. A wc and concrete bottom stair is also at the lowest level its cellular construction and impermeable finishes provide it with some resistance against the flooding.

The upper ground floor level is raised 1050mm and the garden raised by 900mm, this becomes the entrance floor in the event of a flood. The living/kitchen/dining accommodation is split over this floor and the first floor. Capped supplies would be provided to both floors, allowing the usage of the rooms to change over time or in the event of a flood.
Our intention is to provide an opportunity for housing to co-exist with the natural habitat of the flood plain.

Pond House takes aspects of the flood plain such as fertile ground and standing water and incorporates these into key features of the design. The building adapts to its surroundings with the ground floor rising and falling when flooding occurs.

These aspirations are matched by a thoroughly practical solution utilising current methods of construction to realise a comfortable, safe and attractive place to live.

This method will lead to a more sustainable situation reducing the severity and frequency of flooding whilst offsetting issues with drought in the summer months.

“Floating House is a concept for future living and a radical, practical and cost effective response to the necessity of building on flood plains. It promotes waterside housing as a lifestyle choice. It is concerned with the enjoyment of living next to water without fearing the threat of flooding.

The concept is simple. All major house builders invest millions in infrastructure, site clearance, decontamination, ground works and substructure. This investment could be redirected into the creation of a new type of ecological domestic habitat. Instead of cutting and filling to place new homes above the flood risk level, ponds and lakes could be created into which buoyant homes can be floated. The homes would be unaffected by rising flood waters with the surrounding earth berms providing safe dry access.

The houses are modular, adaptable and suitable for lifetime use. They are constructed using known technologies and are net-zero carbon. They are clad in expanded copper that catches and twinkles in the light. This will weather over time, changing from golden orange through brown to green and will become specific to the site and orientation of each house.

On top of each house there is a private roof garden. At ground level, the houses sit within a new man-made landscape that is a place the whole community can share. Here the children can play, wildlife can thrive, renewable energy can be generated, and neighbours can sit together and watch the sun set.

See www.floatinghouse.co.uk for more information.
The main objective of our Flood Resilient House is to foster holistic flood mitigation to minimise the potential consequences of a flood on the property and its occupants.

We have adopted an innovative approach to tackling first stage flood at source that keeps water on site longer, prevents pollution and prevents flash floods. We have also identified issues surrounding the consumption of portable drinking water and how we can instill confidence to the occupiers to cope with floods. This creates a balance between managing storm water, allowing human consumption of potable drinking water and providing settlements with a mechanism to cope with the risk of flooding.

Rainwater is collected from the roof via storm water pipes which flow into rainwater storage tanks beneath the dwelling. Pumps with pressure cells supply rainwater from the tanks for WC flushing, washing and garden irrigation.

Attenuation tanks are designed to provide storm water storage during heavy rainfall but the tanks are primarily designed for a flash flood event. Effluent waste from the dwelling is captured and stored temporarily in a small tank with an external flood valve to prevent mains effluent entering the dwelling.

In extreme floods, the dwelling is designed for multi-purpose occupancy with balconies as outdoor gardens. One of the bedrooms can also temporarily be converted into a living room with access to the garden balcony. The solar conservatory and roof terrace can be used as an alternative garden space for growing foods and provides an added amenity area for the occupants.

The interior of the home is protected against the influx of floodwater, and perishable external property, such as car, shed and contents, are raised above flood level.

A tanked ground floor and automatically triggered flood-activated rising ‘dams’ to external doorways protect the house.

A floating parking and shed deck protects the car and garden equipment, and provides a dry external refuge for transfer to rescue craft.

- Built at ground level,
- Lifetime Homes compliant.
- “Normal” construction.
- The building is tanked.
- Built on raft foundation with all-round upstand walls.
- Lightweight rising caisson cassettes.
- Waterproof barrier and guides at doorways.
- Permeable paving
- Footpaths bounded by swales.
- Floodwater will trigger the caissons and audible and visual warnings indicate that the defences are rising
- Caissons will rise and fall with the water level
- Parking deck fitted with flotation bags.
- A flexible ground to deck link
- The deck accommodates a garden shed.

- An escape window will provide safe access onto the deck.
- Automatic activation, vacant homes are protected
- Fresh water storage, occupants may stay in place.
- Non-return valves ‘holding tank’ to out-flowing foul drains.
- Garden laid to lawn and permeable paving
- Raised planters.
- Automatic and invisible flood defences
- Insurance against flooding.
- Retrofitted to suitable properties.

This idea uses the floodwater in a positive and creative way to prevent homes being flooded.
Ark House

Drawing upon our prior experience of building in flood-risk areas, we believe that solutions at the scale of a dwelling must be complemented by solutions at the scale of infrastructure and policy. ‘Ark House’ is a prototype semi detached home envisaged within the context of larger infrastructures, such that the various levels of potential flood are coped with not a hundred times by a hundred dwellings, but once with infrastructure and dwelling working together.

The home is raised beyond anticipated inundation levels with its territory gently sloping away to the front and rear. Threaded through this earth and concrete ‘bund’ are a series of water channels, collection chambers, a borehole, reed beds, and a broad dike to the rear with a series of walls and hedges above. Water is thereby managed rather than displaced and the home is not compromised.

The bund rises to a waist-high datum within the house interior, providing durable living spaces in the event of the most serious inundations. From this solid base, a lightweight timber house rises, maximising daylight through a three-storey light well at the home’s core, and incorporating a generous raised terrace. Energy supplies are brought in at first floor level and fed down. The servicing of the home, which relies on renewable technology, is particularly directed towards self-sufficient occupation, whilst also supplementing district street lighting systems.

The landscape generated by our design is richly planted with species suitable for a saturated soil or water: a public realm that celebrates its flood-prone setting and is not constrained by it.

Water Lily Concept

Flood Tolerant Design

Recognising that change happens we have conceived a house for the future - focusing upon energy efficiency, sustainability and social responsibility.

The design should let the water in rather than pushing the water to the next area.

Absorbing the water will protect more vulnerable adjacent areas and adaptation will protect the house.

Principles

A floating ground floor ‘pad’ and ‘petals’ that articulate in response to the change in the environment.

The ground floor sits on a floating pad around a fixed central core that houses circulation and services. The height of the ground floor will vary and be taken up by the double articulated joint at first floor allowing all accommodation above this to remain completely unaffected.

Considered design should allow the flood to alter how we use the home but not destroy it. Changing the flood from catastrophe to celebration with minimum disruption and loss to the occupants.
The concept of the flood proof house is to transform the typical semi-detached British town house into a new type of semi-detached house, designed to minimise or completely erase the consequences of the occasional floods.

Its relationship to the existing city structure is celebrated and interpreted so that it in scale and proportion integrates into the urban fabric of Norwich.

The house consists of a band that wraps around two homes. The band protects the house against wind and rain by creating a protecting roof and a water proof base on ground level.

On the 1st floor, where the entrances are placed, a semi-public space is created between the two homes. In this space neighbours can interact and relations between residents of the flood proof house flourish.

In 2007 the studio ‘Phoam Architecture’ was established in Copenhagen by Morten Norup Fassov and Carsten Laursen. This was a consequence of cooperation on projects which as a point of departure had the interest in design based on an unremitting attitude to social and environmental issues of the modern age.

As in the very distinctive design for the flood proof house in Norwich, Phoam Architecture always seeks to capture the essence of the specific assignment in order to provide an accurate response in the form of an innovative architectural and technical solution.

Today the studio has an international outlook and functions as a platform for participation in the architectural discourse.

‘Flamingo House’ is a compact, 3-4 bed, Lifetime Homes compliant, Code for Sustainable Homes level 4, semi-detached house. The design minimizes the impact of a 600mm high flood by stepping out of the flood zone, whilst keeping ‘one foot’ on the ground to ensure Lifetime Homes compliance.

The compact plan makes best use of the available space, providing an interesting yet simple building. Living accommodation is situated over 2.5 storeys, with the ground floor given over to a dining / kitchen, WC and family room overlooking the shared SUDS amenity space to the rear. The living room is connected to this space at the half landing, overlooking over a shared surface street to the front. At roof level is a large, fully accessible roof terrace, taking advantage of views and sunlight.

The ground floor flood susceptible footprint is protected by flood defence measures up to 700mm AFFL. Within the flood barrier is a single flood defended opening: the front door. All other window and door openings within the ground floor are set above 700mm. In principle, the flood defence should not be breached. However, in the possibility of this event, the ground floor (excluding the kitchen) is designed to be submerged with minimum impact to the occupant’s possessions & building fabric.
Cassidy & Ashton

Due to the irregular occurrence of floods, I have prioritised the housing aspects of the design, whilst concealing the floating aspects, to create a space for living that people are used to whilst at the same time effectively dealing with flooding!

Having researched floating homes around the globe, in particular Amsterdam, I decided that the best way to deal with floods was to let them take their course and adapt to conditions. This would protect the home and its occupants in comfort when floods hit. The main construction strategies are as follows;

- Permeable bed around the house soaks up water forcing flooding below the house
- Permeable bed lined with non-permeable clay
- Water is channelled to a tank below the house
- Water creates upward pressure on the bottom of the house
- The house sits on 1500mm slab of polystyrene, coated in reinforced concrete; buoyancy of polystyrene plus water pressure floats house
- Lightweight timber construction method, as the Dutch call it ‘hout constructie bouw’ to minimise weight
- External areas are hard-landscaped to minimise damage to garden

This low-tech design is perfect for prevention against flooding, (because its a passive system it unlikely to fail compared to hi-tech designs that rely on moving parts and manual operation.)

Around the house circulation is fluent to internal and external open spaces. A key feature is the first floor garden; it provides an external space that is appreciated even more so during floods.

To maximise solar gains, the roof tilts in four directions so that one roof top is always facing south, regardless of the site orientation. This house is a passive organism, which caters for current and adapts to future needs of the house regarding floods, environmental issues and changing needs of its occupants.

Makeshift

Topless House

This house is comprised of two elements:
1. An impermeable waterproof shell
2. Inhabitable rooms and courtyards

The shell is built of solid concrete and masonry, with only two openings at 1800mm above ground level. This completely blocks out flood waters, allowing life inside to continue as normal.

All public areas of the house are on the first floor. Two large terraces allow comfortable outdoor living. The bedrooms, on the ground floor, are extremely private and receive light and air by way of two generous courtyards. The smaller bedrooms share a courtyard while the master bedroom has its own private courtyard.

The expected cost for the building is predicted to be no higher than any house of similar size and high specification. No special technologies or additional trades would be required. It is proposed to use a poured concrete wall with brick veneer as the main structure with timber framing inside. The roof would be clad in metal panels.
The ‘Water glass’ House

‘Water glass’ is the trade name for Sodium Silicate”

Our proposal for ‘The Water glass House’ specifically in areas prone to flooding involves the application of a chemical known as ‘Water glass’. It is an odourless, colourless, water resistant, chemical resistant, material, which can be self-cleaning and mixed with existing materials, renders, resins and paints.

Water Glass:

Water glass can be viewed in this application as a reverse form of a ‘fish-tank’ – the glass keeps the water out. Essentially it is a liquid glass applied to housing in flooded areas. Openings at ground level compliment this material by use of glass sliding flood doors, fully sealed. Particular chemicals added to the liquid, as per patent application, allow the water glass to form a tough outer layer when applied

Flood Features:

In addition, we also propose the following architectural measures are implemented;

• Create a hierarchy of importance of ascending spaces above the flood level.
• Waterproof concrete bund construction and resilient water glass application at ground floor level, both exterior and interior & around utilities.

The Float-dam

Our proposal works on the principle of keeping flood waters out of the house altogether and away from the front and rear areas. This has the benefit of:

• Avoiding risk of damage to the house and its contents.
• Allows occupants to live as normal a life as possible while flooding is happening.
• Operates automatically and without the intervention of occupiers or others.

It consists of a concrete chamber containing a buoyant ‘dam’ (1). The Float-dam is conceived as having a polystyrene core with a GRP-moulded facing. The chamber will be in reinforced concrete, with a set of components comprising a ‘shoulder’ lid, grating and connecting elements.

At the early stages of flooding (2), as water flow into the chamber increases, the chamber will fill as the local drainage system begins to fail. On flooding, the Float-dam floats up, pushing open the grating, and rising to a minimum height of 600mm above ground level.

By means of integral side panels linked to garden walling, and through its edge-geometry and water pressure, the Float-dam creates a sealed barrier to the flood waters (3).

When flooding reduces, the Float-dam stays in place until all flood water has drained away from the surface. The dam drops back into its chamber, allowing general cleaning up of the area. The grill will prevent large objects being washed down into the chamber. The Float-dam can be lifted out of the chamber for maintenance or replacement (4).

The system works by itself and does not need any action by the occupier or third parties. It is therefore operable when the occupiers are away, disabled, or otherwise unable to activate other ‘flood-resistant’ systems.

Acanthus LW Architects
Conclusion

In running this competition, we have explored the problem of building on flood plains, and the possible solutions that can be sought in response to this. It is evident that there are still barriers in terms of attitude and cost, and it is essential that stakeholders with an interest in the flooding issue work closely together to ensure that such barriers can be overcome.

We believe that the following points should be an essential part of any new developments on flood plains, and if these are adhered to, then developing and living on flood plains could be possible:

- The overall landscape of the housing development should be capable of absorbing, channelling and storing water which would otherwise lead to flash floods
- Properties should be designed with entry points at relatively high level and with one-way-valve-equipped drainage systems
- Ground-level rooms should be equipped and finished to allow rapid evacuation and clean-up in the event of floods breaching the defences
- Homes and businesses in flood plains should be insulated with closed cell insulation, so that if they are flooded the entire insulation does not have to be replaced.
- Local residents and businesses must be aware of the local flood risk and have an emergency flood response plan in place in case a flood should occur.

In future developments on flood plains, architects need to realise the important role they have to play in terms of mitigating flood risk. As this competition has noted, a variety of responses are available, and this portfolio of ideas should act as a starting point for developers and architects who are considering building on flood plains.

Insurers will insure properties that are adequately defended against floods and where the flood risk is evidently mitigated. In the future, insurers and property developers need to work much closer together, to ensure that homeowners and businesses are able to purchase properties that are both insurable and sustainable in the long term.

Government also has an essential role to play. Strict planning controls must be enforced and adhered to, to ensure that inappropriate developments in flood risk areas do not go ahead. Where properties are developed on the flood plain, they must include a joined up approach to flood risk management, building upon some of the ideas set out in this competition, and using the natural surrounding environment to help.

Flood risk management needs to be viewed in a much more joined up manner so that we can continue to develop areas where people want to live, and are protected from flooding.
Jury panel and selection process

Launched in August 2008, this competition, to design a flood-proof house for the future, attracted 85 entries from 13 different countries, including entrants from Australia, Malaysia and the USA. All entries to the competition were judged in two stages: firstly, a specially selected Jury Panel met and decided on the final shortlist; secondly, we interviewed the shortlisted entrants, asking them to explain their ideas in further detail. From this, we decided on choosing four overall ‘winners’, as each of these designs addressed the flood threat problem in very different ways.

In their decisions, the Jury Panel members were asked to consider each scheme in relation to:

- The ability to integrate flood mitigation measures
- Effectiveness of flood mitigation proposals
- Innovation and creativity
- Cost effectiveness and buildability
- Sustainability
- Adaptability to climate change and future needs

For the first stage of judging, each scheme was displayed in an anonymous fashion with no identifying marks other than a number given by the RIBA Competitions Office. For the second stage of judging, the Jury Panel met with the shortlisted architects and talked through their proposals.

“Norwich Union would like to thank the Jury Panel for their contribution to this competition.”
Management
Linda Roberts,
RIBA Competitions Office

Prizes
4 x £3,500
1 x £1,000

Jury Panel
Simon Black
Head of Data and Statistics,
Norwich Union

Simon Black is the Head of Statistics & Data at Norwich Union. In this role he has worked on Norwich Union’s flood mapping and also worked on the ABI and Government working parties reviewing the ABI’s Statement of Principles for Flood Insurance. Simon joined Norwich Union in 1989, and since then, has held numerous senior roles within the company, including Head of Pricing for Norwich Union Direct, Head of Pricing for Intermediary Brokers and Head of Reporting.

David Birkbeck
Chief Executive, Design for Homes

David was formerly editor of Building Homes magazine and has been CEO of Design for Homes since the company formed in 2000. He has broad expertise in residential development as a researcher, writer and consultant. He manages the Housing Design Awards and sits on the board of the Housing Forum.

Kiran Curtis (Chairman, Jury Panel)
Principle, KCA Architects

Kiran Curtis is the founder and managing director of KCA architects. Over the last decade Kiran has established KCA as an award winning design led practice with a passion for improving the built environment, and through work in the Thames Gateway, KCA have developed innovative new urban design strategies for development within the flood plain.

Kiran and the practice are increasingly engaged by the challenge that climate change presents and in seeking positive and practical ways to make development sustainable. KCA architects sit on the RIBA/CABE Building Futures Panel and Kiran’s paper ‘Question Time’ was published in the RIBA Flooded Futures Publication in 2007.

Steve Cook
Policy Manager, Flood Risk Strategic Overview, Environment Agency

Steve Cook is part of the Environment Agency’s Policy team for flood and coastal risk management in England and Wales. He leads the organisation’s policy production and advocacy on its strategic overview role, spatial planning and flood risk, surface water management and Catchment Flood Management Plans. He has been extensively involved in advising on the Government’s national housing development agenda for England and regional spatial and economic strategies on flood risk, spatial planning, sustainable development and climate change. Prior to joining the EA in 1999, Steve worked for over 10 years as an ecologist and environmental consultant in the public and private sectors both in the UK and abroad.

David Levitt OBE
Consultant, Levitt Bernstein

David Levitt MA RIBA OBE co-founded Levitt Bernstein, in 1968. At the same time the two founding partners started what is now one of the largest charitable housing associations in south-east England. As the practice has grown to over 100 people the scope of its work has necessarily increased to include urban design and major regeneration projects as well as every kind of housing, Since the commission in 1972 to design the Royal Exchange Theatre in Manchester, the practice has had a constant programme of buildings for the arts, most recently the restoration of St Luke’s Old Street, the Theatre Royal Bury St Edmunds and the Colston Hall in Bristol.

Hugh Pearman
Editor, RIBA Journal, and architecture critic, The Sunday Times

Hugh Pearman has been architecture critic of The Sunday Times since 1986, and now also edits the RIBA Journal, the official monthly magazine of the Royal Institute of British Architects. He was one of the original founders of the RIBA Stirling Prize for architecture, is a judge for numerous competitions and awards, and is a frequent contributor to BBC radio arts programmes. Among his books is the bestselling “Contemporary World Architecture”, published by Phaidon.
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