Adaptable Infrastructure

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Introduction

In the Netherlands, the available space for new housing projects is relatively limited. Solutions can be found by building (temporarily) in those areas, which are sensitive for construction. As it is on a temporary basis, (light town building) its construction might be allowed. A different option can be housing on water. Although the Netherlands has quite a vast open water area, we will not find many houses built on water. These two options require, both, an adaptable type of infrastructure. This paper is referring to two Msc theses of TU/e students who did extensive research in this field. It can be divided into a 'dry' and a 'wet' part, which is also symbolic for the Dutch countryside.

2. Infrastructure as a problem

Infrastructure is needed to facilitate transport of:
1. people and animals,
2. goods (products, water, waste, waste water),
3. energy (gas, electricity),
4. voice/data.

The fast changing requirements in urban areas, in both housing and office buildings, lead either to demolition and new construction, or to rehabilitation and re-use. Sometimes, this requires also a change of infrastructure, around these buildings. Often traditional infrastructure has a technical lifespan longer than the economic lifespan. After ending its period of economic use, most of the components are left obsolete and un-used as they are not designed and made for re-use.

3. Design for lifespan

The TU/e research unit for Architectural Design and Engineering developed the design for lifespan approach: "design and select the components and its connections in such a way that they function in accordance with the wanted lifespan".

Different types of lifespan can be distinghuised, which are also applicable for the infrastructure. With regards to economic life span and technical life span we adopted three life span scenarios, these are the basis for environmentally sound designs [Durmisevic]:

A. Economic life span < Technical life span.
   The components of this infrastructure should be re-usable and/or recyclable.
B. Economic life span = Technical life span.
   The components should be recoverable and than recyclable.
C. Economic life span > Technical life span.
   The components of the infrastructure should be replaceable and recyclable.

The design efforts should be such, that the resulting products are sustainable. This requires thinking about environmental effects and should include options for re-use, replacement and recycling.

4. Infrastructure on land

When designing infrastructure, the first consideration should be the real demand for it. Through smart design, the need for infrastructure on land can be reduced:

1. Reduce the need for infrastructure by applying other options. Use techniques which are located close to the housing unit and think of autarchic options; but also,
2. Replace a provision by using a different one. For example cooking on electricity reduces the need for a gas pipe, if also heating is done differently.

In other papers [Erkelens 2004], we elaborated the options for light infrastructure on land. We just summarize them here:

- Rainwater: is filtered into the bottom around the building.
- Gravel chests are used to infiltrate the rainwater falling from the roof.
- Waste water; with the use of modern septic tanks (e.g. the IBA system) waste water is received, purified and drained into the bottom. Once a year the remainder has to be taken out of the tanks either to use as compost in the garden, or to use somewhere else.
- Telecommunication is wireless and by air.
- Roads can be provided with an aquaflow system, which does not require a storm water drainage.

During his MSc. thesis research Verkuijlen [2003] developed a simple infrastructure model for gas, water and power. He developed a duct system, in which those mains can be placed and can be coupled with others, for other directions. By doing so, the mains are concentrated at one location; easily, accessible and exchangeable. This prototypical design has further to be modeled in the nearby future.

5. Infrastructure on water

Building on water is getting increasingly attention. For the Netherlands this is obvious; lack of sufficient space in urban dense areas, the abundant availability of water and the seasonal floodings. So that it is better to ‘join’ the enemy (water) than to combat him. Already we see sites with floating green houses, residential houses.

Building on water requires special constructions. Commercial firms have developed different house types, and transport them over water to the required location. Special factories manufacture these units while these float from one production stage to the other. The construction of these houses doesn’t raise much problems. However, field observations show us a number of problems, when looking at the connection between land and floating object. Figures 1 and 2 show lines for sewer, water and power, which are not well fixed and supported. It seems that during the design stage this hasn’t been discerned and in the execution phase the contractor have to solve the problem, but not properly as it seems.

Figure 1. Mismatch of infrastructure (1)

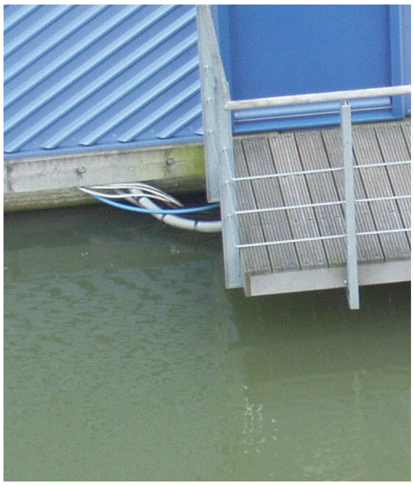

Figure 2. Mismatch of infrastructure (2)

At a greater scale we experienced similar problems with the single buoy moorings used for the transfer of crude oil from the seebottom to a tanker in full see. Rubber reinforced houses were used, but after a period of time the dynamic loads tore of the house and heavy spillage occurred.

In order to solve the signalled problem the following items will have to be reviewed:

A. floating systems,
B. mooring systems,
C. forces on the floating unit,
D. (infrastructural)connections between land and floating objects.

Ad A. The figures 3,4,5 and 6 below show the different floating systems which can be applied to create a floating bottom for the foundation of a housing unit. It is done similar to ships: a single or double lined steel hull, see fig. 3; a hollow concrete hull filled, see fig. 4; a reversed concrete hull but filled with foam, see fig. 5; or with a framework of hollow steel or synthetic tubes, see fig. 6.

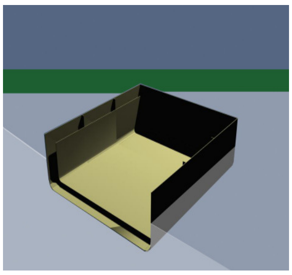

Fig. 3. Steel hull

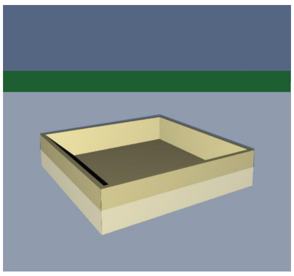

Fig. 4. Hollow hull

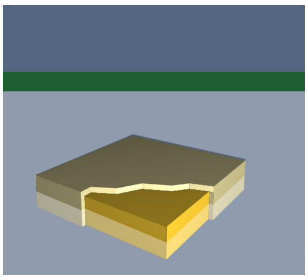

Figure 5. Reversed hull

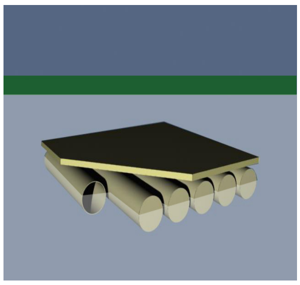

Fig. 6. Hollow tubes

Ad B. The systems can be positioned with a flexible connection to piles, which are driven into the bottom or with cables and anchors, although the latter does not fix the position in a stable way.
The connection with the land may be either via an also floating mooring system or directly to a fixed landing stage.

Figure 7. Mooring systems

Ad C. When looking at the connection between A (land) and B (floating object) there are vertical & horizontal forces and bending & torsion moments, Fig. 8. These forces (and moments) are caused by: the changing levels of the objects, the flexibility of the water, the tidal movements, the dead weight, the point of gravity and the loads due to the use. All these cause different movements. By applying special joint these forces and moments can be transmitted or changed into a different type of force.

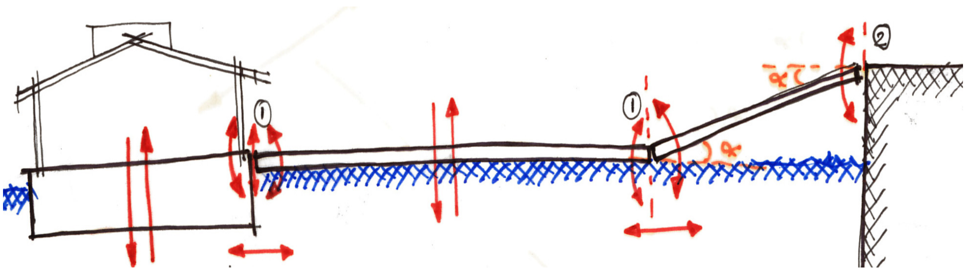

Figure 8. Impression of acting forces and moments on jetty, connection and floating house

Ad. D. The designed connections. The thesis has worked out a proper connection between the floating object and the mooring of which Fig. 9 shows more details. Whereby the following remarks can be made with respect to specific problems which had to be solved:
- (Flexible) lines for water, power, sewerage and data transmission were placed in a hollow insulated tube, between land and floating objects with special shivels.
- The real joints consist of hinges. At the land side we find a number of hinges consisting of vulcanized rubber and at the object side is a ball bearing hinge.
- A chain connection prevents the system from overloading in the event of a sudden break down of the hinges.

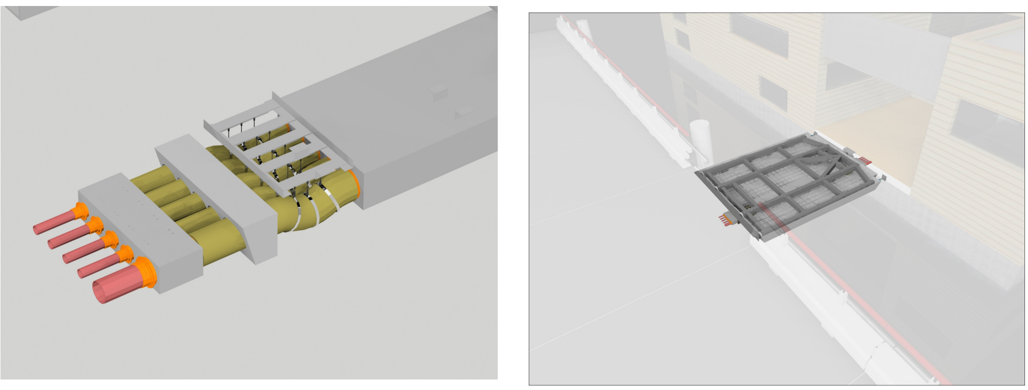

Figure 9. Model design of an adaptable connection between land and floating object

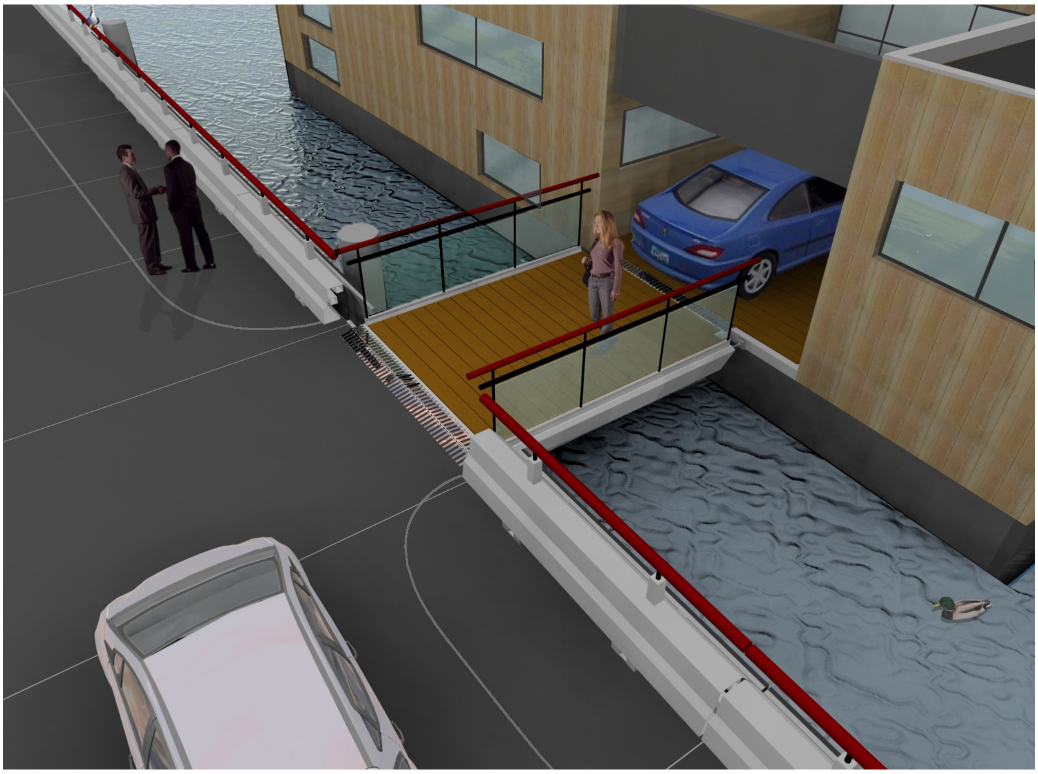

Fig. 10. An artist impression of the final design

6. Conclusions

1. Adaptable infrastructure is a promising answer to the fast changing requirements of a demanding society.
2. The design and production of an adaptable connection is challenging and feasible.

7. References

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