Tuning infrastructure to buildings with a short lifespan

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ABSTRACT: To date, experiments are carried out on buildings with a short economic lifespan. This type of building has a number of typical characteristics. The main idea is that the economic lifespan = functional lifespan. The technical lifespan of the components may last longer as these components can be re-used elsewhere, so there will be no waste.

In terms of lifespan also the external infrastructure like roads, lines for water, gas, power and communication can be adapted to this type of building, making its economic lifespan = functional lifespan.

The advantage of an area consisting of both buildings and infrastructure with a short lifespan is that the area can be re-used for other purposes after a period of time. Along the same lines more vulnerable areas or areas with a planned use but for a far future can be used.

The paper presents ongoing research at this University on the issue of (temporary) infrastructure especially designed for these types of buildings. It presents design issues on the one hand and practical solutions on the other hand.

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INTRODUCTION

Today but more in particular in the nearby future, we are facing a shortage of fossil energy. Also the building industry and most buildings are using this form of energy.

In order to overcome this growing problem, there are more ways and means to face this situation. On the supply-side we can think of shifting from fossil energy resources to ‘endless’ sources, like solar energy and wind energy.

But on the demand side we can stimulate reduction of energy need during both construction and use of buildings. This demand reduction can be achieved in more ways:
• reuse of whole buildings
• design buildings in such a way that they need less energy during use
• design buildings with less materials by smart combination of these materials and details
• make use of recycled materials and products leading to less depletion of resources and less waste
• design buildings and infrastructure lasting for a predetermined lifespan.

This paper will go into further detail on this last option.

2. DESIGN FOR LIFESPAN

As can be learned from practice buildings, infrastructure and areas are facing an overhaul after every period of time. Buildings, offices in particular, are renovated after approximately 15 years. Shops are undergoing refurbishment, after a few years, while housing units are renovated either partly or completely after 15-30 years.

Also infrastructure: roads/streets, telecommunication, cables, gas, water, power are undergoing renewal and improvement in a relatively short period. As this is the case, a philosophy has been developed to fit the designs more to the foreseen lifespan [1].

When considering a building consisting of a frame and an infill, in this context three variations are possible:
1. The frame of a building is made for a long period but the infill for a shorter period.
2. The frame and infill of a building last for the same period whereby the functional quality of the infill may be decisive for the length of this period (see Fig. 1).
3. A set of buildings with different lifespans of both frame and infill, which is a mix of both 1 and 2.
3. ELABORATION AND EXAMPLES

The design for lifespan philosophy can be expanded to a larger scale, to areas and suburbs. ‘Light town planning’ is one of the assigned interdisciplinary projects of this Faculty under the Uso-Built research program. This project aims to develop ideas and techniques for towns, which can easily be removed after a predetermined period of existence. The advantage is that urban areas can be realized at locations, which:
- do not have yet a final plan for spatial use,
- are vulnerable for urban developments in the long run but can sustain a shorter period of urbanization.
- are needed for temporary housing to accommodate after disasters etc.

The following Table 1. gives an impression of the issues to be dealt with when supply buildings for different lifespan. The matrix needs further elaboration in the coming years. More research and knowledge has to be acquired to make the right design decisions.

| Table 1: Building technology model (under construction). © J.M. Post [2] |
|--------------------------|-----------------|-----------------|------------------|-------------------------|
| Demand                  | Supply          | Medium          | System            | Realized example       |
| Short term: 1-5 yrs     | Temporary       | Special Units   | Open system       | Japanese Pavilion     |
|                        |                 | Special Materials|                  | Hannover Expo         |
| Middle term: 15-75 yrs  | Fixed lifetime  | Traditional     | Closed system     | XX-project             |
|                        |                 | Building Site   |                  |                         |
| Long term: 100-200 yrs  | Endless         | Flexible        | Mixed system      | DutchPavilion at      |
|                        |                 | Demountable     |                  | Hannover Expo         |
|                        |                 | Infrastructure  |                  | Double use             |

With this model in mind it is very important to choose suitable materials, which do not burden the environment. For example the project XX (Delft) and the Children’s Art Gallery (Rotterdam) have an excellent quality for their intended lifetime. The XX office design, is planned to last for 20 (=XX) years. After this period the building will be deconstructed, and most of its components can be reused for the erection of an other building, more adapted to the then contemporary requirements. [2]

For the development of the XX project eight requirements were formulated:
1) used materials are restored in their natural state after 20 years
2) parts can be re-used without any adaptation
3) parts can be reused after adaptation for other applications
4) materials can be fully recycled
5) the building by its flexibility and appearance remains functional for the users
6) the building with regards to architectural and technical detailing must be transparent & of high quality
7) the building must be exploited conforming the real estate market
8) the building must be code compliant.

When building for a predetermined lifespan, one should not only think of building on land but also on water. Floating structures are especially of growing importance for the Netherlands.

4. INFRASTRUCTURE FOR DIFFERENT LIFESPAN

We will now further focus on infrastructure in relation with lifespan of its servicing buildings. This is an item of concern. For example in Canadian cities rehabilitation of infrastructure is a big and complicated issue and it is costing a fortune. The contemporary infrastructure has not kept pace with the rapid economic and technical developments of the cities.

Traditionally the contemporary infrastructure, which serves buildings, has a “normal” lifespan as it is built according to the standards applicable. It appears that this lifespan is longer than the lifespan of a building. The consequence is, when at the end of the economic lifespan, the building is deconstructed, the infrastructure for this building becomes redundant.
This is not the case if a new building will be erected right at the same spot. But, it can also occur that the whole built area will be redeveloped. Infrastructure with a longer lifespan can be an obstruction when it still remains there. On the other hand, removal and/or demolishing can be seen as unnecessary capital waste.

Elaborating this problem along these lines the following (research) question is of interest: How would an infrastructure look like if it has to serve buildings for a predetermined functional and economic period, which is in general shorter than what we are use to?

From a point of view of the user of a building 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.

For some of them exist various options:
(i) through physical connections (roads, lines and cables),
(ii) by air, through wireless transmission for example antennas, airstrip,
(iii) provision by the building self or its direct environment through autarchic techniques.

Table 2 presents a general overview of possibilities

<table>
<thead>
<tr>
<th>Transport to be provided for:</th>
<th>Category</th>
<th>Physical connections between building and elsewhere</th>
<th>Wireless connections and self supportive provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living creatures</td>
<td>people</td>
<td>roads/canal/rafthip moving lanes</td>
<td>helicopter</td>
</tr>
<tr>
<td>Goods</td>
<td>animals</td>
<td>moving lanes</td>
<td>helicopter</td>
</tr>
<tr>
<td>Water</td>
<td>products &amp; goods &amp; waste</td>
<td></td>
<td>rain water harvesting, -</td>
</tr>
<tr>
<td>Waterlines</td>
<td>water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste water</td>
<td>waste water</td>
<td></td>
<td>rain water harvesting, -</td>
</tr>
<tr>
<td>Water lines</td>
<td>bottled water</td>
<td></td>
<td>rain water harvesting, -</td>
</tr>
<tr>
<td>Rain water</td>
<td>sewer lines</td>
<td></td>
<td>sink/stone tank/compost</td>
</tr>
<tr>
<td>Energy</td>
<td>gas</td>
<td>gas lines, power lines of batteries</td>
<td>earth heat/</td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In conclusion, the need for some infrastructure varies from fully dependent to none (being self-supporting).

5. DESIGN FOR INFRASTRUCTURE

Three Msc students (Kos, Verkuijlen en Van Schijndel) have been working on different issues in relation with temporary infrastructure. When designing for lifespan of infrastructure, the first idea was to elaborate this for a period of 20 years (the XX option).

Comparing to buildings with a shorter economic lifespan, there are also specific advantages for having an infrastructure with a shorter economic lifespan in an area. Meanwhile this will solve the contemporary problems with infrastructure.
- Reuse is possible due to easy demounting.
- Capital waste as well as other waste can be reduced.
- Less damages during reconstruction activities because of other concepts.
- As infrastructure and buildings have a shorter economic lifespan, there may be more chances to build in vulnerable areas, "closer to nature" [6].
- Infrastructural changes, causing street blockings may occur less frequently.
- There are more possibilities to adapt infrastructure to changing circumstances and wishes even within the foreseen economic lifespan.
- Options for changes may already be built-in.
- Different materials may be applied, which may cause a lower environmental impact.
- Less maintenance needed within lifespan.

Infrastructure between floating objects and land is a source of particular concern with yet unsolved problems (see Fig. 2 below).

Figure 2: Lack of good infrastructural connection [7]

5.1 General

When designing infrastructure, the demand, the required capacity and combination of provisions for infrastructure must be taken into account. This can be done along the same lines as when designing for durability:
1. Reduce the demand. Try to reduce the need for infrastructure (e.g. the use of drinking water will fall to 2.5 litres ppdp. at present it amounts to 48 litres [8]
2. Reduce the need of a certain provision of infrastructure by using a different type of resource. E.g. with energy: (traditional) gas for heating and cooling can be replaced by electricity. With data/voice transmission: a computer with an Internet connection may take over the role of other voice/data transmitters.
3. Use endless or renewable sources, if possible. This asks for shift from conventional to towards autarchic solutions.
4. Make closed systems in terms of energy use and materials use: Infrastructure systems should function as ecosystems whereby energy, water and waste streams should flow in closed circuits [9].
5. The infrastructure should consist of renewable, reusable, recyclable materials and components in order not to deplete our resources.

5.2 For a specific lifespan

Infrastructure for buildings with a shorter economic life (say 20 years) can be designed in different ways [5]. Two (+ one) options can be thought of: 1) Infrastructure with an economic lifespan longer than the buildings to be put up in the area. This longer lasting infrastructure could be placed in a different way in order not to hinder future changes in the area. For example, decide to place a "permanent type" of infrastructure up to the point where you can connect ("plug in") to any position of a new building; In this case we can think e.g. of a radiant shaped network of infrastructure. The components may have a shorter technical lifespan than the economic lifespan, which means they should be replaceable and recyclable (design rule C, chapter 2).

2) Infrastructure with an economic lifespan 'equal' to the buildings in the area. This asks for a shorter economic lifespan than usual. In this case components may have a longer technical lifespan than the economic lifespan, which means, according to design rule A, a system whereby the components are re-usable and/or recyclable. This asks for demountable solutions but also other forms can be thought of.

3) A combination of both options (1 and 2) depends on the type of infrastructure. The use of the 'frame and infill' concept for infrastructure design can be the underlying philosophy. Which means the basic infrastructure is permanently available but the new infrastructure has to be "filled in" and connected with the new building to be erected (design rules C and A). This asks partly i) for components that are replaceable and recyclable and ii) for components, which are re-usable and recyclable.

6. RESEARCH RESULTS

Interviews with energy suppliers showed that the quality of the materials and components being used for contemporary infrastructure is far more better than strictly needed for a shorter lifespan: It is difficult to find materials and components with a shorter lifespan.

From the interviews was also learned that companies do research into improvements of components and products. However they do not put it on the market too early as they expect the revenues in future.

Based on interviews and literature survey we made an overview of the requirements for the provision of gas, power and water for the contemporary situation. We also indicated possibilities for a shorter economic lifespan, an XX-area situation. Although based on the Dutch situation, the results may be interpreted for other countries as well. We will only show a few of the results [10].

Commonly used for gas:
- Topside of gas pipes (diameter 110 mm) is at 800 mm minus ground level
- PVC/PE or HDPE, of which the latter is mostly used as a pipe material
- Connections of a rubber ring put in place with force in the joint.

In an XX area:
- Lying at a higher level is possible
- In that case steel pipes are advised

Commonly used for water:
- Topside of water lines (diameter 160 mm) is at 800 mm minus ground level
- Asbestos cement (in the past) and today PVC and sometimes wrought iron is used
- Load due to traffic is sufficiently reduced at that level
- Connections consist of a rubber ring put in place in the joint

In an XX area:
- Lying at a higher level is possible
- Provisions for insulation may be needed

Commonly used for power:
- Topside of cables 230/400 V at 600 mm minus ground level
- Cables are provided with a coating and the connections are watertight.

In an XX area:
- Lying at a higher level is possible
- Cables should be provided with an iron "mantle" against damaging
- Connections with 'plugs' can be considered.

The philosophy developed for the infrastructure in a so-called XX area has the following features:

1) Above – underground: In order not to hinder traffic the infrastructure will be placed underground. From interviews it was found that traffic would have problems when crossing above ground provisions. It is also advised for reasons of vulnerability and cooling.

2) For reasons of reconnaissance infrastructure should follow the streets pattern, which will also have a short lifespan. In case buildings in an area will be rebuilt at the same spot the streets / infrastructure can be reused. In case buildings are renewed, also streets and / or infrastructure can be changed.

3) In the Netherlands the IFD (industrial, flexible and demountable) concept under development has a number of advantages for infrastructure as well. Therefore we should seek for industrialized solutions, which also should be flexible; easily adaptable to future changes and demountable. This satisfies the requirement that everything can be removed without leaving traces after ending the functional/economic period.

7. PROTOTYPICAL DESIGN

Departing from the above design rules, requirements and ideas, different provisional designs were made for gas, water and power. At this stage we selected...
the idea of a gutter of approximately 10-meter length and 50-75 cm wide. The gutters are put in line and fixated with 'connectors'. The gutters and the connectors have a cover in order to prevent damage. They will be situated underneath the footpaths in the streets. From the gutter the lines for gas, water and power are put at a specific position. Water and gas pipes will have the same length as the gutters and have clamping connections with rubber rings. Power cables have their full length and are connected with plugs. The connections with the buildings are made at the location of the 'connectors'. See Figure 3. Of course this prototypical design needs further elaboration.

During the use period. At the same time the feasibility of this concept has to be worked out from point of view of the users, producers, environment, costs, and benefits.

CONCLUSION

1. Thinking in terms of lifespan for both buildings and infrastructure is getting more and more a realistic issue. Designers should adopt this attitude in the future.
2. From the interviews could be concluded that the development of a temporary infrastructure is needed.
3. As far as this preliminary research has shown, it is possible to design infrastructure with a shorter functional lifespan than usual.
4. By applying the IFD concept, it is expected that the environmental impact will not more but even lower than when using traditional systems; as there will be no waste, but re-use and recycling opportunities.
5. Incentives from more parties should speed up changes in infrastructure development.

REFERENCES