245: SmartRenovation: a new approach to renovation

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Abstract

The Dutch Architecture Union stated in a building magazine in 1948: "There is no reason to believe that houses and districts, that meet the specified demands, will lose their utility in the next one hundred years". The actual practice has turned out to be different. Post World War II terraced houses face demolition after fifty or sixty years, because these houses do not live up to today's demands. Every year, approximately 20,000 houses are being demolished, creating huge amounts of debris. At this pace, it will take over 300 years to replace the entire Dutch housing stock. This is obviously far too long.

Three strategies to solve this problem can be distinguished. Of these, renovation is the best option regarding waste reduction and preservation of the societal structure of the post World War II districts. Unfortunately, renovation is generally not chosen by housing corporations, mainly because of the impact of the operation and the required participation of the occupants.

SmartRenovation is a new approach to renovation. It forges links between the housing corporation, the architect, the occupants and the contractor by offering a toolkit for upgrading the post World War II houses in a fast and efficient way by adding prefabricated units to either the front or the back of the house.

Keywords: renovation, energy saving, building system, upgrading, post World War II houses, housing stock

1. Introduction

After World War II, the demand for houses in the Netherlands was enormous. Large housing construction programs (terraced houses and apartments) were established by the government in the fifties and sixties. Because houses were scarce, the construction time was limited, and therefore some standard layouts for terraced houses were developed. In every Dutch city, many of these standard houses have been built in large series and are owned by housing corporations.

The typical Dutch terraced house has two floors and an attic. Figure 1 shows that the ground floor is divided into two banks. One bank holds an entrance hall, a toilet, stairs and a kitchen and the other a living room that stretches from the front to the back. On the first floor, three or four bedrooms can be found as well as a small bathroom providing a shower and a wash basin. The attic is accessible by a loft ladder.

The houses are approximately 5.5 metres wide and 7 metres deep. The structure consists of wooden or concrete floors, and brick cavity walls with a cavity of approximately 50 millimetres. The floors span between the walls separating the different houses and a load bearing wall separating the two banks, allowing the two façades to be quite open, because they do not have to bear the load of the floors.

As cities were a lot smaller in the fifties and sixties, the houses are situated close to the city centres in a spacious composition offering a large amount of green space, a front and a back yard. Unfortunately, the houses described above are nowadays regarded as being too small. Especially the bathroom (approximately 3 m^2), kitchen (approximately 6 m^2) and living room (approximately 24 m^2) are considered tight. A second disadvantage is the poor energy performance these houses offer. A typical Dutch (post World War II) terraced house uses approximately 113,000 MJ primary energy for heating each year, which equals 3,500 m^3 natural gas per year (calculated according to the Dutch EPC norms). There is no thermal insulation, the windows are single glazed, the construction is not airtight and the installations are outdated.

In the near future, the Dutch housing sector will face major problems. However, in 1948 the perception was different. At that time the Dutch Architecture Union stated in a building magazine: "There is no reason to believe that houses and districts, that meet the specified demands, will lose their utility in the next one hundred years" [1]. The actual practice has turned out to be different. The post World War II terraced houses face demolition after fifty or sixty years, because they do not live up to today's demands and standards regarding room for living and energy performance.

Approximately 20,000 houses are being demolished each year. At this pace, it will take over three hundred years to replace the entire Dutch housing stock. This is obviously far too long when these houses are being dismissed after fifty or sixty years. Moreover, demolition means creating large amounts of debris and destruction of capital. A single house weighs approximately 130 tonnes, which is as much as a

large aeroplane. To make the existing post World War II terraced houses suitable for today's demands, an enlargement is necessary and the energy performance should be improved.

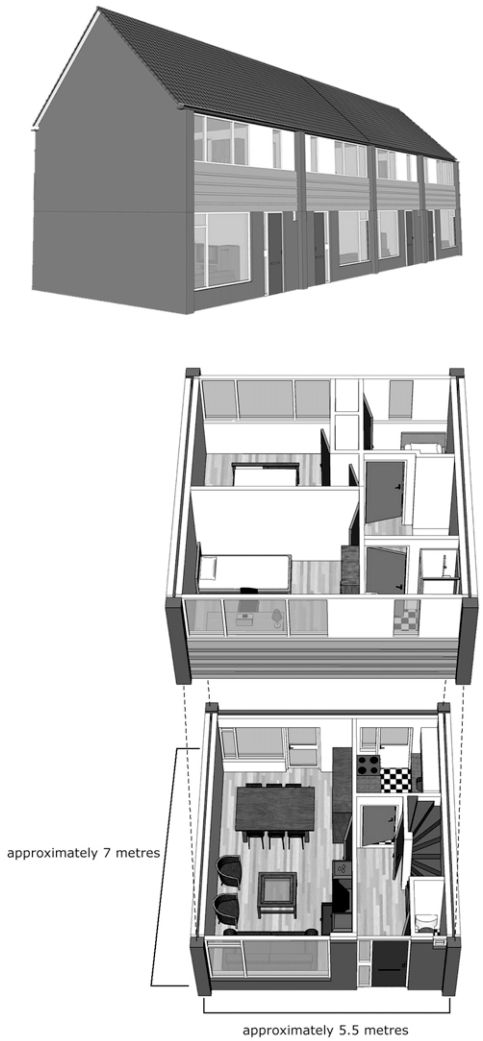

Fig 1. Typical plan of a Dutch post World War II terraced house. On the ground floor, the right bank holds stairs, a toilet, a hall and a kitchen and the left bank holds the living room. On the first floor, a bedroom, a hall and a bathroom can be found in the right bank. The left bank holds two bedrooms.

This paper introduces a new approach to solve the problems of the post World War II terraced houses. This approach is titled SmartRenovation. In the next chapter the origin and the ideas of the SmartRenovation approach will be explained. In chapter 3 the design and the energy performance of the measures will be discussed and in chapter 4 the results that can be achieved are summarized.

2. Approach

2.1 Strategies

To solve the problems mentioned above, three strategies can be distinguished:

1. Increase the amount of houses that will be demolished and replace those with new ones. The new houses will offer a better energy performance and will be built according to the latest standards for quality and comfort. Unfortunately, this approach creates large amounts of debris, means destruction of capital and the occupants are forced to leave their homes. They are generally not able to return after new houses have been built, because the price level of the new houses will be significantly higher.
2. Expand the cities by building new districts on vacant sites on a larger scale and leave the existing houses unaffected. This approach involves new districts attracting many people who can afford a new house and leaves the districts from the fifties and sixties with a very monotonous societal structure and unoccupied houses. In this way the post World War II houses' problems are not solved at all. Furthermore in the Netherlands undeveloped land is scarce. This is a second major disadvantage of this approach.
3. Large scale renovation of the existing housing stock, extending the life span of the houses involved. Although this approach might have some disadvantages regarding the building quality and energy performance that can be achieved, there are significant advantages. The creation of huge amounts of debris can be avoided, capital will not be destroyed, the existing societal structure remains and the occupants are not forced to leave their homes.

Nowadays, renovation is not the housing corporation's favourite alternative, because renovation is relatively expensive and requires participation of the occupants on a high level. In most cases, the occupants have to leave their homes for a few weeks or months, for which they receive a compensation fee. Besides this, the occupants nearly always have strong resistance to renovation plans presented by the housing corporations, because they fear increase in rent and nuisance. If this strategy is applied, the energy performance of the houses should be improved and the living space has to be enlarged.

2.2 Renovation

It might be obvious that the third strategy has the best advantages regarding the restriction of waste and preservation of the societal structure of the post World War II districts. On the other hand, the housing corporations are facing some problems regarding the price and the impact of the operation and the required participation of the occupants when applying this strategy. Therefore, renovation is not a common strategy chosen by housing corporations. In order to make renovation suitable for the housing corporation, the occupants and the environment, these problems should be solved.

2.3 Actors involved

In order to solve these problems, not only technical aspects should be taken into account, but an integral design approach is necessary.

Many different parties are involved, each having their own point of view and concerns. Five main actors can be distinguished: the housing corporation, the occupants, the architect, the government and the contractor.
The first actor involved is the housing corporation, which has to decide what to do with the existing terraced houses. To make renovation affordable for the housing corporation, renovation should be less expensive compared to building new houses and the occupants should be convinced easily.
The occupants are other important actors involved. For them, minimizing the nuisance of the renovation and the duration itself are crucial aspects as well as the influence they can have on the measures taken and the increase in rent involved in those measures.
Besides the housing corporation and the occupants, three other main actors in the field of renovation are the architect, the government and the contractor. The architect has to ensure the quality of the overall appearance, converting the old monotonous rows of houses into a new and fresh environment with respect to the existing context and the requirements of the housing corporation and the occupants. The government sets the regulations and therefore affects both the urban planning and the minimum energy performance required. The national government is involved as well as the local government, which can determine additional regulations or ambitions regarding energy performance. The contractor is responsible for the execution of the renovation and therefore he puts cost, construction method, construction time and the reduction of labour by building workers first.

3. Design

3.1 Integrated design approach

Keeping all the different actors and their interests in mind, a new approach to renovation is established: SmartRenovation. The concept is based on previous research into new concepts for renovation [2]. SmartRenovation forges links between the housing corporation, the architect, the occupants and the contractor by offering a toolkit for upgrading the post World War II terraced houses by adding prefabricated units to either the front or the back of the house. These units enlarge the room for living and add energy efficient measures like thermal insulation and new installations. In order to connect the prefabricated units to the post World War II terraced house, openings in the façade need to be made and a special connector is used. The openings are subject to the configuration of the façade, as an example shows in figure 2.

Fig 2. Configuration of the façade. The openings that will be created are shaded.

After the openings are made the connector is placed which then ensures a fast and accurate placement of the prefabricated units. This way the nuisance for the occupant in the interior is restricted to a maximum of two days and will contain the creation of openings in the existing façade and the fastening of the connector to the façade.
Before and after the placement of the prefabricated units, all the work should be concentrated on the exterior only and is limited to a maximum of two weeks. To ensure a short building period and to make the houses adaptable to changing demands in the future, the system is designed according to the Slimbouwen® philosophy. This philosophy states that the building process should be organized in such a way, that installations, pipes and canals are installed in a single step in the construction phase, ensuring a clear, efficient process without interference of other disciplines. Besides this, the separation of structure, installations and finishing ensures flexibility both during construction and in the future [3]. Of course not only space will be added, but the energy performance will also be improved by adding thermal insulation and double glazing to the existing façades, roof and ground floor and adding new installations.

3.2 3D connector

The connection of the prefabricated units to the existing structure is the key to success for the SmartRenovation concept. Instead of attaching the units directly to the existing structure, a three dimensional connector is developed in order to solve the design problems mentioned below and to ensure a two day placement period. On one side, the connector is able to cope with deviations in size of the existing structure. On the other side, the prefabricated unit can be attached in a fast and accurate way. Like the units, the three dimensional connector is prefabricated, thus the connection between the units and the connector can be tested during manufacturing. The connector will consist of two storeys just like the structure of the house. Because the post World War II terraced houses vary in width and height, the dimensions of the connector and the units will have to be determined at the start of every SmartRenovation project.
The connector is also important for the architectural appearance. On the corners of a

row, there is a glass panel, visually separating the existing house and the new part.
By adding the prefabricated unit, the depth of the living room will increase, which means that the amount of daylight in the interior will decrease. By using a glass roof and a translucent first floor in the connector, additional daylight can enter the living room, creating a lighting row in the ceiling. Besides the increase of daylight in the living room, the separation of the old and the new part can be experienced from the interior as well.

Fig 3. SmartRenovation in the front yard. The 3D connector separates the old and the new part.

3.3 Flexible design for occupant and architect
The prefabricated unit has a standardized construction method, but will support a flexible design for the architect and the occupants. A structural frame forms the basis for the architectural appearance. The shape of this frame is fixed and acts like a 'signature', but the architect is free to choose a suitable and attractive cladding. Within the structural frame, the architect can use his creative imagination to create a configuration for the façade and the layout of the different functions, in close cooperation with the housing corporation and the occupants.
Although some measures (like the depth of the extension and the enlargement of the bathroom on the first floor) are fixed, the occupant will be able to choose from a couple of predetermined options, designed by the architect and the housing corporation. For example the occupant may choose for either a new kitchen or enlargement of the living room on the ground floor. On the first floor the choice might be either expansion of the bedroom or a balcony.

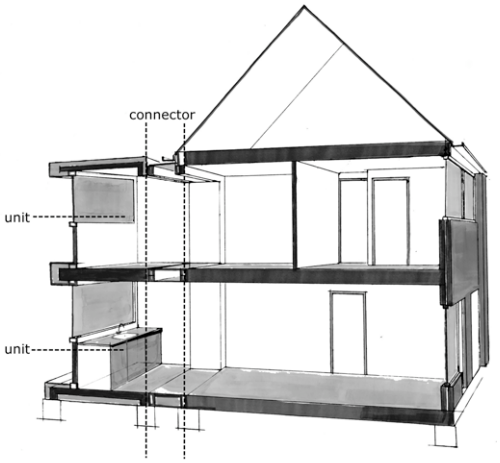

Fig 4. Section showing the SmartRenovation system with two units and the connector. In this situation, the occupant has chosen to implement a new kitchen in the lower unit.

3.4 Installations and connections
Because in most cases the installations in the houses involved are outdated, new and more energy efficient installations will be added. To accommodate this, an installation zone is implemented in the prefabricated units. This zone will offer space for a new, energy efficient boiler, a ventilation system and other necessary equipment. A connection with the existing meter cupboard will be made, providing cold water and electricity. A new connection with the drain soil pipe will be made as well. The pipes for water and electricity will be accessible from the interior and can be adjusted to meet new demands in the future. When an occupant chooses to expand the living room, the piping should accommodate a fast and proper placement of a new kitchen at a later stage. This is all done according to the Slimbouwen® philosophy.

3.5 Energy performance
Although it might be clear that the SmartRenovation approach offers great advantages regarding waste reduction and future adaptability, the energy performance of the houses involved should improve dramatically to make them ready for the future. The connector and the unit will be built according to the latest standards for thermal insulation and airtightness. Besides this, the existing house will have to be upgraded with thermal insulation in the exterior walls, the roof and the ground floor, double glazing and new installations (mentioned in the previous section). The housing corporation has to decide what measures should be taken exactly. Table 1 indicates what energy savings can be achieved with a couple of common measures, compared to a traditional Dutch terraced house, using the Dutch EPC (Energy Performance Coefficient) calculation method.

Table 1: Possible energy savings (E.S.) and the influence on the EPC value. The energy savings are calculated using primary energy.

Measure	E.S.	EPC
Standard post World War II terraced house	0%	3.72
Low-E double glazing	31%	2.57
Low-E double glazing, thermal insulation (Rc = 2.5 m^2K/W)	44%	2.09
Low-E double glazing, thermal insulation (Rc = 2.5 m^2K/W), improvement of the airtightness (quality level 'good')	57%	1.59
High efficiency boiler	26%	2.75
High efficiency boiler, Low-E double glazing	51%	1.84
High efficiency boiler, low-E double glazing, thermal insulation (Rc = 2.5 m^2K/W)	61%	1.46
High efficiency boiler, Low-E double glazing, thermal insulation (Rc = 2.5 m^2K/W), improvement of the airtightness (quality level 'good')	71%	1.06
SmartRenovation extension (3,25 m), Low-E double glazing, thermal insulation (Rc = 2.5 m^2K/W), improvement of the airtightness (quality level 'good')	65%	0.97

The EPC is the coefficient used to express the Energy Performance Norm (EPN). It is an indicator for the level of energy efficiency of a building [4], which can be calculated using the formula:

EPC = Qpres,tot/(330 x Ag;woon + 65 Averlies)

With:
Qpres;tot: the characteristic primary energy use (MJ)
Ag;woon: the total living area (m^2)
Averlies: the area of the building skin (m^2).

The lower the EPC value, the better the energy performance is. According to the Dutch building codes, an EPC value has to be calculated for every new building. For new houses, the EPC value should not be higher than 0.8. The EPC for a typical Dutch post World War II terraced house is 3.72 according to the EPC calculation. As some assumptions are made in the calculation, the percentages and the influence on the EPC values mentioned in table 1 are an approximation for use in the design phase only.
Because the building codes only set rules for the EPC values for new houses, hardly any attention is paid to the energy performance of existing buildings. Although every house has to be labelled with an Energy Performance Label, which is derived from the EPC value, no limits are set for the energy performance of existing houses. Keeping the four million existing dwellings built before 1970 in mind [5], it is obvious that the largest energy savings can be achieved by improving the existing houses instead of concentrating on the relatively small energy savings that can be achieved by building approximately 80,000 new houses every year.

3.6 Passive house quality

It might even be possible to establish passive house quality, which means that it will be possible to heat the house by using the ventilation air to transport the heat trough the building [6]. In that case a traditional water-based heating system is not necessary and thermal comfort can be provided by reusing the thermal energy stored in the polluted air that leaves the house and an additional electric air heater. The demand for heating should not exceed 15 kWh/m^2 per year with a maximum peak load of 10 W/m^2 [7]. Adding a balanced ventilation system, improving the airtightness and improving the thermal insulation (optimum between 150 to 350 millimetres [8]) are the most important measures involved. Beside this, the passive use of sunlight should be supported in the design, but the risk of high temperatures in summer conditions should be avoided. Because passive houses are very susceptible for mistakes made during construction, maximum attention should be paid to the design, the construction method and the actors involved. For example, the demands for airtightness are significantly higher than the traditional Dutch building methods. If the contractor is not capable of meeting these demands, the heating capacity will be too low, resulting in an uncomfortable house. All the actors, including the architect, the contractor and the occupants, should support the passive house concept in order to make it successful.
Although it will be possible to create a passive house using the SmartRenovation approach, the measures for converting the existing house into a passive house are not included in this research.

4. Result

By implementing the SmartRenovation approach, it will be possible to upgrade the Dutch post World War II terraced houses on a large scale. Approximately 1.2 million houses are involved in the Netherlands [9]. At the moment, mostly houses from the thirties and forties are being demolished. But within a few years post World War II houses too will face either demolition or renovation. Demolition will result in a huge amount of debris, and societal structures will be destroyed. Renovation can be successful on a larger scale only if both comfort level and energy performance improve and the nuisance for the occupant is minimized. SmartRenovation integrates these aspects in a systematic design. Societal structures will not be affected as the occupants will be able to stay in their homes both during and after the renovation process. The energy performance can be improved dramatically and the comfort level will increase as extra space and new installations will be added.

Although the government's ambitions and regulations focus on the energy performance of

new houses, huge amounts of energy can be saved by improving the existing houses. With SmartRenovation, the post World War II terraced houses can be improved fast and on a large scale, resulting in an energy saving which is significantly higher compared to the amount of energy that can be saved by paying attention only to the energy performance of the relatively small number of new buildings.

5. Acknowledgements

SmartRenovation is the title of a research project within the Slimbouwen® research program, part of the Architectural Design and Engineering (ADE) unit at the faculty of Architecture, Building and Planning of the Eindhoven University of Technology.
Our special thanks to the Eindhoven municipality, who made it possible for us to attend the conference.

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