

# Mass Customization in Housing an Open Building/ Lean Construction Study<sup>1</sup>

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**Abstract:** The housing industry in the Netherlands is gradually shifting from a sellers to a buyers market. In order to satisfy the customer's needs, builders developers shift from mass housing to mass customisation. This paper links the principles of Open building to Lean Construction and reports on the findings of a study on mass customised housing in the Netherlands. The Open Building concept suggests to introduce different levels of decision making in the building process: tissue, support and infill, respectively referring to the urban fabric, containing base buildings with their fit-outs.

Lean Construction is the building and construction equivalent of lean production, a manufacturing method that aims to reduce 'waste' in the broadest sense of the word.

Fourteen housing projects were studied. In the final analysis, Lean Construction principles were translated to be applied on mass customised housing. This has resulted in the following suggestions.

- Value: Determine what the customer (end user) expects as the added value, to be delivered by the builder;

- Value stream: Deliver the wanted added value. Decision making and price forming are combined in a typology matrix;

- Flow: Optimise the production process. A lead time diagram was developed to identify and avoid potential conflicts, Open Building techniques are suggested to streamline the construction process of mass customised houses;

Pull: The builder who listens, hears the client's wishes. Satisfied clients are the best agents to generate new clients. In addition, it is the source for innovation;

Perfection: Continuous improvement. The steps from Value to Pull can be repeated in the next project.

**Keywords:** mass customized housing, Open Building, Lean Construction

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## INTRODUCTION

The housing industry in the Netherlands is gradually shifting from a sellers to a buyers market. This has serious consequences for all partners in the building industry in general and for the developer builders in particular.

Late 1999, the OBOM Research Group was approached by the Foundation for Building Research (SBR) to look into the latest developments in consumer oriented building in the Netherlands. OBOM is a research group at the Faculty of Architecture of the Delft University of Technology and is specialised in Open Building research and development. The SBR is funded by the large developing builders in the Netherlands. Its main aim is to support the building industry with relevant studies. The controversial architect and ex-chairman of the Royal Institute of Netherlands Architects, Carel Weeber, had published an article in a Dutch newspaper, with reflections on mass housing. As an alternative, he advocated a high degree of user participation, called 'gewild wonen' (desired living). In the header of the article he was misquoted as 'wild wonen' (wild living), which suited his image well. 'Wild living' became hot, in the Netherlands and when the municipality of Almere, with a long reputation of experimental housing and urban planning, looked for a theme for their 25th anniversary in 2001. Fourteen developers were invited to build nineteen projects. There were two restrictions: No two dwellings should be the same and all dwellings should be designed according to the dwellers wishes. SBR anticipated that Almere was an interesting playground to explore the combination of mass produced housing and consumer influence, or as it is called in the industry of consumer goods: mass-customisation as a potential new strategy for builders in a shrinking market. This study is based on three presumptions.

- Consumer with spending power will become a major driving force in the housing industry, therefore, the building industry needs to take the consumer seriously;
- The consumer must not interfere with the construction process;
- Open Building and Lean Construction provide solutions to solve the potential conflict between consumer and construction.

First the basic ingredient of this paper are presented. Open Building and Lean Construction are introduced in brief and the Almere project is explained. 'Lean' thinking as the underlying principle of Lean Construction is applied to derive recommendations from the Almere projects.

## 1 OPEN BUILDING

The *raison d'être* of Open Building can be expressed in terms of care, responsibility and technology. People, who care about the environment they live in, will make it a better and safer place. Therefore the built environment must encourage people to take responsibility for their own territory. An environment that clearly distinguishes those spaces and parts of a building for which

occupants should take responsibility, will address the user's needs to feel responsible. Therefore a building should be designed and built in such a way that both spaces and parts of the building can be clearly allocated to those parties and individuals that should take responsibility for them.

Buildings, which are designed and built with separate systems, can create conditions for responsibility and care. Therefore the subdivision of the building process needs to reflect the lines of decision making and the definition of responsibilities between the parties. This subdivision can then be translated into specifications for connections between building parts. This in turn creates buildings that can be modified and taken apart again .

It offers the basis for a well-structured building process with well-defined interfaces. It allows us, to at least partially transfer the construction process from building to manufacturing. It is the key to reducing waste by co-ordinating dimensions and positions instead of improvising on site by cutting to size. Applying information instead of energy.

This is an important condition to re-use building parts, thus extending the lifetime of building parts, without the waste of dumping and recycling, coinciding with degradation and the use of energy.

## **2 LEAN PRODUCTION AND LEAN THINKING**

Lean construction is a construction management concept that originated in the late eighties of the past century. The American and European car manufacturing industry was in a deep crisis and saw their market share decreasing, while the Japanese car makers took over. Research of the IMVP (International Motor Vehicle Program) made clear that car manufacturing in Japan had deviated from America, which had always set the example with mass production of cars. WWII had changed the word and Japan faced import as well as export restrictions. The local market was too small for mass produced cars, such as the T-Ford and the Volkswagen Beetle. They were forced to look into ways how to assemble different cars in small production runs on the same production line. Toyota was the first in successfully adapting car manufacturing American Style to the Japanese circumstances. The change-over time of the production line was considerably reduced, long term relationships with sub contractors opened the way to just in time delivery and the relationship with the end users were vital in determining future car programs. This became known as TPS, the Toyota Production System, or in more general terms, 'Lean Production'. This is very well described in 'The Machine that Changed the World' (Womack, Jones, Roos, 1990). These ideas caught on and there is no manufacturing industry, these days, not applying one of these ideas involved. The adoption of Lean Production was not limited to the manufacturing industry, many others, like services industries such as the travel, healthcare, financial, telecom and energy industry, to mention a few, are not 'lean' at all. The house building industry was mentioned in the same category. Lean Production guide lines were described in more general terms as 'Lean Thinking' (Womack, Jones, 1996).

It can be summarised in five steps:

- Value: determine what the customer (end user) expects as the added value;
- Value Stream: deliver the wanted added value;
- Flow: Optimize the production process;
- Pull: Optimization of the production process is directed by 'pull', the clients wishes, rather than 'push': selling products, not asked for;

- Perfection: continuous improvement.

### **3 LEAN CONSTRUCTION**

Lean Construction is inspired by Lean Production and aims to apply lean thinking to the construction industry. The basic principle of 'lean' is to reduce waste: 'specifically any human activity which absorbs resources but create no value'. (Womack, Jones, 1996, p. 15). 'Lean Construction results from the application of a new form of production management to construction. Essential features of Lean Construction include a clear set of objectives for the delivery process, aimed at maximising performance for the customer at the project level, concurrent design of product and process, and the application of product control throughout the life of the product from design to delivery' (Howell 1999).

### **4 OPEN BUILDING AND LEAN CONSTRUCTION**

A superficial comparison of Open Building and Lean Construction suggest that they have much ground in common. They both originate from dissatisfaction with traditional second wave industrial production that was felt at approximately the same time. The principles of lean production were first adopted in the early sixties in Japanese car manufacturing. At the same time discontent with mass housing of the post war-housing boom in The Netherlands resulted in the introduction of different levels of decision making in the housing industry. The base building ('support') and fit-out ('infill') were treated as separate entities, with different life cycles, in order to build an environment that can respond to individual needs of the dweller. Open Building is a multi-faceted concept, with technical, organisational and financial solutions for a built environment that can adapt to changing needs. It supports user participation, industrialisation and restructuring of the building process. If change is the problem, a layered organisation of the building process can provide at least a part of the solution. Positional and dimensional co-ordination of building parts and their interfaces are a tool and a condition for industrialisation and probably a leaner construction process.

Open Building and Lean Construction can complement each other, what they have in common is the sympathy they feel towards lean thinking. Open Building is concerned with the quality of the built environment and the way it is established, from initiative, via decision making, design, construction and real estate management. 'Lean Construction rests on production management, the "physics of construction"' (Howell, 1999).

### **5 ALMERE**

Almere is one of the Dutch towns built on reclaimed land, within commuting distance of Amsterdam. Since all reclaimed land is municipality owned, Almere has the potential for consistent town planning, contrary to old towns with a high degree of private land ownership. In most of the cities in the Netherlands, developers have assured themselves of political influence, by

selectively buying property. Almere prides itself by being a experimental environment in housing and planning. In 2001 a new lay out of 450 dwellings was completed. It consists of nineteen projects, varying in size from seven to seventy units. As part of the experiment, it was demanded that all units had to be different. In addition, there was complete freedom in where to position the dwelling on the individual block of land. This is quite uncommon in the Netherlands, where town planning usually prescribes strict building lines.

The results were presented in a two-week building exposition, with commercial exhibitions and a generous amount of Almere promotion. All projects had at least two units open for inspection as exhibition homes.

All projects had time and place in common, thus cancelling out two variables, which was an ideal combination for comparison and analysis. Especially the narrow timeframe has jeopardised a full consumer orientation. At least two exhibition homes per project had to be open for inspection during the exposition, September 2001. In addition the builders had to remove their building equipment before the exposition. Most of the builders preferred to finish the project and not come back, rather than returning after the exposition. If the future dweller was not known yet, most of the houses were completed in a neutral fashion. If it did not meet the potential buyer's taste, the dwelling had to be refurbished, as if it was an existing building.

## **6 THE ALMERE MONITOR**

When OBOM was commissioned by SBR to evaluate the consumer oriented housing projects in Almere, the limited number of consumers, involved in making decisions about their own house and the underlying reasons were not known yet. When this became clear, it was decided to shift the emphasis from evaluating the consumer - builder relationship to evaluating the construction process. Questions about the consumer - builder relationship could not successfully be asked, lacking a sufficient number of buyers. In addition, due to the time pressure caused by the building exposition, the builders has little time to spend with the researchers. Open Building provides useful concepts to structure decision making. Lean Thinking, as the derivative of Lean Production', gives us the vocabulary to evaluate the consumer orientation of the process.

## **7 PROJECT DOCUMENTATION**

Of a total of thirteen Almere projects information was gathered on the following subjects:

- Process;
- Design;
- Construction, including building methods and time planning in relation to consumer participation;
- Consumer support.

First project documentation was collected, about the consumer support, such as brochures, CD-ROMs, interactive web sites, card board cut out models and so on. In addition factual information was collected, such as building data plans, a state of materials and drawings of construction details.

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The projects were visited and recorded on photographs and key persons were interviewed, to complete the research data, and to learn more about the background of the projects, experiences and future do's and don'ts.

Based on this information, per project a documentation was written according to a fixed format.

As the database grew, it became clear that the following aspects were taken into consideration, be it differently per project:

- Marketing by communication. In a buyers market, developers need to change their marketing strategies relative to the sellers market they were used to;
- Transparency in decision and price making. The consumer in a buyers market is more demanding than in times of scarcity of dwellings;
- Consumer confidence in the construction industry.
- The importance of after sales services;
- Feedback to marketing;
- Threats from and opportunities for urban planning and rule giving.

The documentation of projects made clear that there is not a single concept of 'consumer oriented building', every party applies its own definition. In addition there is a great variety in size and position of different parties involved. It is therefore impossible to give general guide lines towards a consumer oriented building that satisfies both consumer, developer and builder. This growing insight changed the ideas about the outcome of this study: Not tips how to become successful, rather than recommendations as food for thought, in order to explore and stimulate different ways to satisfy the client, the end user and in the final analysis, the quality of the built environment. Traditionally, the building industry is better in dealing with clients than with consumers as end users. It is neither 'open', nor 'lean'. Since Open Building and Lean Construction concepts offer aspects that could be instrumental to consumer satisfaction, the recommendations were developed along the lines of lean thinking: value, value stream, flow, pull and perfection.

## **8 VALUE**

The first step towards a lean, thus consumer oriented construction process is to determine what the customer (end user) expects as the added value. In a seller's market counts what the developer, being the builder's client, wants. Cost and quality can be cut without the penalty of building houses, that cannot be sold. In a buyer's market, the client has to listen to the end-user, in order to fit the demand. If not, the potential buyer may decide to vote with his feet.

Finding out what the end user wants and letting him know that the developer / builder has got something to offer is very much a communication issue. Therefore, choosing the most appropriate communication medium is important. The Almere projects showed a wide variety of ways to communicate, from broadcasting, such as adds in daily newspapers or the free weekly's, to narrowcasting, such as direct mailings to tenants of an Almere housing corporation. The chosen media ranged from a simple artist impression to cut out card board models, CD-ROMs and interactive web sites.

In order to pick the right scope of 'casting' in combination with the most appropriate medium, the developer / builder must have a well defined idea about what to communicate. In a buyer's market, communication has to serve a multitude of tasks. In order of reach, the following can be mentioned:

- finding a buyer. This has never been a point in a seller's market: the buyer looked for a seller;
- informing a potential buyer. There is little profit in informing a buyer in a seller's market. The buyer buys anyway;
- interviewing an potential buyer, finding out about his preferences. Building it right the first time is better than modifying a newly built house;
- serving an buyer. After completion the buyer becomes a dweller and is prepared to spend extra money on maintenance, refurbishing, and extending the house or moving to another place. These are all potential sources of additional turn over;
- following a buyer. A satisfied buyer is the developer / builder's best promoter. It is also a source for information about new trends in consumer appreciation and preference.

It may be clear that value is not limited to the end product, being the dwelling, rather than referring to the whole process of selling, building and living, for years to come.

## **9 VALUE STREAM**

The next step is to deliver the added value, as expressed by the consumer, not only in terms of end product, but of process as well. An open, lean, consumer oriented building process does not mean that an infinite number of options has to be offered. In a tailor made house, the single desired option is enough. An infinite offer of variety is the other extreme of consumer satisfaction. This approach includes a lot of redundancy, thus waste, of which the bill will finally be presented to the consumer. Waste is not 'lean'. In a process of mass customisation, a limited number of options can be sufficient. This is a strategic decision, that will differ from company, market segment, location and time. In all cases it is important to keep the customer satisfied. He wants to know the selection to choose from and how to choose and since every option is measured against the available budget, the consumer wants to know the cost implication of every combination of options.

In Almere three ways to assemble choices for the new dwelling were detected:

- Add. The system to chose from, consist of a minimal core building, containing the major services, such as bathroom, heating, ventilation and facilities to connect a kitchen. The consumer can determine the size of his house, by adding modules. In the Almere case, with small lots, the drawback of this system was that the core building looks small, whereas everybody, including the neighbours, tend to buy as much volume for their money. Choice by adding hides the worst case scenario's of being built in by other houses;
- Subtract. In this system the complete buildable envelope is given and the dwelling of the consumer's choice is assembled by subtracting modules. The neighbour's house will never outgrow the given maximum envelope;
- Base building + space allocation for dwellings. This is a system of a larger superstructure, to be subdivided and allocated to dwellings of different sizes.

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The client wants to know the cost consequences of his choices. Three ways to determine the price were adopted.

- Basic price plus options. Every option is priced and the total costs are determined by totalling the basic price of the dwelling and the options;
- Basic price plus shopping. Only the basic dwelling is priced and purchased. Extending of finishing the core building is up to the new owner, he has to shop on the construction market to contract somebody to do the job;
- Basic price plus contract overruns. Every option is compared with a reference house and priced accordingly as a contract overrun. This has always been common practice in the construction industry in a seller's market. The initial price looks modest as first, but can grow out of hand easily. It lack transparency. Since builders are familiar with this system, there is no additional cost that goes with pioneering new systems.

Ways to choose and ways to determine the total costs can be related to each other in a typology matrix. When applied to Almere, it shows, that most of the investigated projects collect in the lower left corner, where 'adding' and 'pricing options' meet (Figure 1).

selection \ price forming	add	subtract	base building+ space allocations for dwellings
basic price + shopping			
basic price + options			
basic price + contract overruns			

*Figure 1 Typology matrix*

## **10 FLOW**

Once the value issues are dealt with, the construction process needs to be streamlined accordingly. Consumer interest in the making of their new home can easily conflict with the efficiency of the building process. The consumer who looks for a new house is about to go for the largest expenditure of his life, he has to choose between an existing and a newly built house. The developer of new dwellings has to win the confidence of the new dweller for the quality of the builder. A transparent process and a building of the agreed quality are thus essential.

### **1.1 Lead time diagram**

A short production time, from initiative to completion is advantageous for all parties concerned. A quick process reduces the chance of buyers stepping out and diminishes loss of interest. The consumer may make choices about this new dwelling in an order that does not comply with the construction order of the building. In addition, the consumer needs rather more than less time to choose. In order to avoid delays by an undecided consumer, the developer / builder can influence the decision making process by preparing the order and the moments of choice. The lead time is the time between the moment of decision and the actual start of the execution, the related building activity. Insight in the different lead times helps to improve the planning of the construction process. The minimum lead time is not only related to the construction method, but also to the consumer, who has to decide. The latter is a hard to control and can jeopardise the construction planning. A lead time diagram consists of a vertical time line, with two columns. The right hand column represents the construction moments, the left hand column the decision making moments that precede the construction activities (Figure 2).

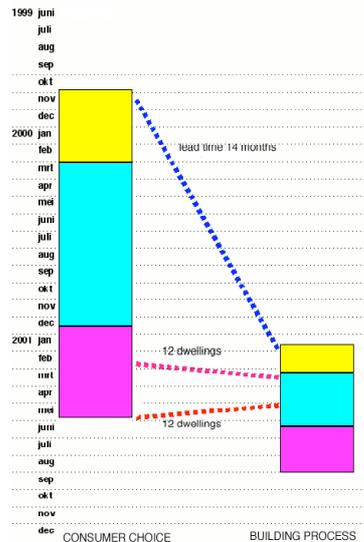


Figure 2 Lead time diagram

Lead time diagrams can be used to analyse finished projects, but they can also be drawn from projects in the design stage. Analysis of lead time diagrams can result in measures to improve the planning.

## 1.2 Quality embedded in the applied construction methods

Another wildcard in consumer confidence is the unpredictability of the construction quality. Traditionally this depends on the skills of the trades people on the building site. The quality is enforced by lengthy contracts and supervision and quality control. There is an incentive on delivering minimum quality for the agreed price. Application of off site prepared fit outs makes it easier to create value without waste. New load bearing constructions that accommodate flexible ducts and services as well as complete infill systems are being developed in the Netherlands to serve this aim. The modern kitchen industry leads us the way. Was it a multi building job, forty years ago, now it is a manufactured product that can be installed by plugging it in.

## 11 PULL

In a lean process, optimisation of the production process is directed by 'pull'- the clients wishes - rather than 'push': selling products, not asked for. The builder who listens, hears the client's wishes. The communication activities of step one (value) should be extended towards after sales services. Satisfied clients are the best agents to generate new clients. In addition it is the source for innovation.

### **1.3 After sales service**

Satisfied customers are a valuable commodity of a marketing business. The satisfaction should not be limited to the dwelling, but should also include the act of living. It therefore pays to keep in touch with the dweller, after completion and if desired, to offer services such as maintenance, repair en refurbishing. It is not only the basis for future turn over, it is also a source for learning and improvement of the organisation. The sales representative plays a pivotal role in translating the consumers wishes into pulling the production process.

### **1.4 The importance of the sales representative**

After sales services serve many aims. It starts after the sales contract has been signed. It keeps the interested consumer away from the building site, thus preventing interference. The sales representative thus acts a buffer between consumer and construction. He is the front office the larger organisation. The personal attitude of the sales representative is important in the way the consumer feels himself treated. A satisfied consumer spreads the positive message, attracting the attention of new potential clients and is the best promoter a selling organisation could wish. The sales representative, if he has won the trust of the consumer, can remain the only contact for building related problems and solutions. This not only can result in additional building jobs, thus additional turn over, it also keeps him in touch with the latest trends in consumer wishes. It could even result in a relationship of trust, evolving in some kind of loyalty program with incentives, in which the consumer takes the initiative to pass information about housing an living. The sales representative is the key person in a consumer oriented and pull directed construction industry and should stay connected to the company over a long period of time.

## **12 PERFECTION**

The steps from Value to Pull can be repeated in the next project. The should not be copied, but applied after evaluation only, in order to continuously improve the process and thus the product. From the viewpoint of lean production, perfection should be found in the internal process. Since lean production originates from manufacturing (creating value in a fixed factory setting) and lean construction from building (creating value on sites with different conditions), it is a matter of lean thinking to look for perfection opportunities from outside the construction process as well. In this approach, additional recommendations were made with regard to external influences. Not all aspects of consumer oriented building are within the sphere of influence of the developer / builder. The master plan is a top down condition, determined on a higher level of decision making and is hard to negotiate, bottom up. However, it is the result of a decision making process and influences the consumer's choices. For example, if the position of the house on the block is a consumer choice, which was the case in the Almere projects, it can change the physical conditions for others.

### 1.5 Lean master plan

In a lean process, the master plan should also be developed, with 'lean' considerations in mind. The master plan prescribed nineteen different projects, to be built in a short time frame. This resulted in a congestion of a variety of site offices, inventory of building material, moving equipment, delivery trucks and so on. Disruptions in the production process create waste and cost, of which the bill will be presented to the end consumer at last.

### 1.6 Lean urban department

The developer / builder can specialise in a consumer oriented building and will establish a well suited information exchange with his clients, the dwellers of his buildings. The urban department of a municipality, by its own nature does not have a public function, it deals with professionals only. If a municipality, such as Almere initiates consumer oriented building, it should be prepared for individuals, involved in the making of their new house, to visit and ask for master plan related information, or else keep the developers informed.

## 13 CONCLUSIONS

This study is based on the hypothesis that a builder who serves the client, can compete best, thus improving his prospect. The development of the Almere suburb offered the opportunity to compare and evaluate twelve out of nineteen housing projects that were built within the same time frame and conditions. The study aimed at identifying pros and cons of consumer oriented building and at developing guidelines for builders who want to survive in a buyer's market. The study proposed to draw lead-time diagrams to visualize the degree of customer influence on, and interference with the building process. This is done by mapping different lead times for different decisions.

The growing consumer influence will direct the building process. How can professional building partners, including the contractors and developers, determine the level of consumer influence? If this can be achieved, there is a means to anticipate on and improving consumer influence, satisfying the consumer, thus improving their own position in the building process.

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