

## THE DANISH EXPERIENCE FROM 10 YEARS OF PRODUCTIVITY DEVELOPMENT

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### Abstract

Over the last ten years a number of sector analyses and development programmes have been carried out in Denmark with an aim to increase productivity within the building sector. This has been undertaken in a continuous co-operation between the authorities, the research institutes and the industry itself.

The paper reviews this development and highlights positive as well as negative experience. From the review it appears that a systematic increase of productivity is possible. However, it is also apparent that there are barriers that have to be surmounted, if a successful change from craftsmanship into a modern industry shall take place. The experience gained is concluded in seven preconditions, which have to be fulfilled for a development programme to give permanent results.

Key words: productivity; development; re-engineering; Denmark; programme administration;

### INTRODUCTION

Since World War II Denmark has established a widely recognised tradition for developing the building industry through a co-ordinated effort between the Government, the building research environment, the customers through the social housing associations and the industry itself (Nielsen and Bertelsen, 1997). In the 1960'ies this effort resulted in the Open Danish Building System, a highly efficient prefabricated and modular co-ordinated concrete slab system, capable of providing high quality housing at low cost. The system became an inspiration for the development of industrialised building systems over great parts of the world (Nissen, 1972).

In the 70'ies the high rise dwellings went out of fashion and the Danish building sector had to introduce a complete new product almost over night, and most of the processes on the construction site were transformed. Even if the modular co-ordination was still in operation, making it possible to keep the manufacturing of building components such as cupboards, windows and rafters as industry, productivity went down in accordance with the trades' return to the construction sites. Building went to some extent from industry back to craftsmanship.

Today an understanding of the loss by this transition is growing in Denmark. Several initiatives have been taken to raise the building site productivity again but the road back is rough. Not only are the concrete high rises a scaring example of the architecture of yesterday – and few love their parents' ideals – but social problems in the 60'ies' new urban areas add to the dislike too. And the efficient industrialised building systems are blamed for the problems. However, a new understanding seems to be on its way.

The paper reviews for the first time the more important productivity development programmes and sector analyses undertaken, in progress or planned, within the Danish building sector during the last fifteen years. Based upon this review it outlines some preconditions for the establishment of successfully programmes for the development of the building sector. The paper is narrative rather than documentary, as no formalised research in the subject has been undertaken as yet.

## **DANISH PROGRAMMES AND ANALYSES – A HISTORIC VIEW**

### **Re-development of the Multi-storey Housing**

This competition was launched 1983 by the Ministry of Housing. The idea was to give new life to industrialised building of high rise dwellings by new structural systems allowing more flexible use of the buildings.

The winners proposed a plate-column system which combined with the prefabricated component production led to a substantial technical development in order to solve the structural problem with force transmission from the corners of the slabs to the columns.

The programme was reviewed 10 years after the competition at a time when 12 buildings had been erected (Bologministeriet, 1994). This unimpressive number indicates, that the use of the principles met with some barriers. Most important were the technical and economical barriers. Due to size restrictions for components to be transported and need for structural strength at column-slab connection, the structures became too expensive, compared to the limited freedom obtained in the dwellings between the many columns.

However, the programme started close co-operation between companies interested in sector development.

### **The Ministry of Housing Development Quota**

Since 1989 a portion of the governmental social housing scheme has been reserved for experimental projects in either the area of product or process development. It was a deciding factor at the outset, that the industry participants in the experiments should play a major role to ensure the use of the results in their future building projects. At the same time the industry participants should carry the major part of the additional costs associated with the development. Priorities were put on testing building systems or the building process as a whole, instead of the development of components or tools.

A wide range of ideas has been tested under this very broad programme making the target hazy. However, two projects stand out clearly as a basis for the further productivity development. One was the development of the Building Logistic principles introducing a completely new approach to the materials management, inspired by the Japanese Just in Time philosophy (Bertelsen and Nielsen 1997). The ideas were successfully tried out in a series of six consecutive projects from 1992 to 1996 demonstrating a productivity gain of app. 10 percent (Agapion et al, 1998).

The other project was the development in 1991 of a new building system – ECO-byg – based on steel frames and gypsum panelling as an alternative to the prefabricated concrete structure normally used in the Danish housing projects. Besides being cost effective, this new system turned out to provide higher insulation, better indoor climate, as well as a reduction of noise transmission between apartments.

Even if these two projects were successful as experiments, they had very little impact on the building sector as such. The 'ownership' to the Building logistics principles was not clearly established, meaning that companies capable of and willing to utilise them were not identified wherefore all went back to normal practise once the experiments were completed. And the ECO-byg system did not find a commercial market outside the development quota. However, the two experiments were to become a major part of the basis for the later PPB-programme.

### **The Technological Counsel's Programme for the Data Exchange in the Building Sector**

This programme, jointly financed by the Ministry of Industry and the building industry, was carried out in 1990 to 1994. It involved a great number of companies from the industry, who also undertook the management of the programme. Its objective was to establish standards, procedures and recommendations for the exchange of digital information in all phases of the building process.

The programme established the basic infrastructure for the use of information technology within the building sector, with a focus on the very important exchange of data between the participants. At the same time it caused the establishing of a Danish organisation for the users of Electronic Data Exchange (EDI) within the building sector. By this, the programme became the basis for the Ministry of Housing's recent recommendation for the data format of electronic as-built information. The programme was also a major prerequisite for the development of the inter-firm use of IT in the later PPB-programme.

### **Double Up**

Between 1991 and 1993 the Danish Association of Consulting Engineers undertook a study of the development potential in the Danish building industry. The study was supported by the Ministry of Industry. The objective was to investigate ways and means to improve the productivity at least to the level reached during the industrialisation in 1960'ies without any loss in quality. The specific aim of the project was to exploit the booming German market (F.R.I, 1991).

Strongly inspired by the work of the American economist professor Michael E. Porter it was proposed that the building sector should be viewed as a whole, including the building materials manufacturers and whole-sale dealers in the sector (Porter, 1990). It was recommended that the domestic building projects to a great extent should be looked upon as vehicles for a further development to strengthen the industry's competitiveness. A demanding home market should be seen as the source for ongoing development of the competitiveness.

It was further recommended that the building industry should establish permanent supply chains through a vertical integration, making learning from past experiences and the development of new procedures easier. And the analyses outlined a new role for the whole-sale dealers as masters of the logistics. It was found that this stronger co-operation could raise productivity dramatically, ease the usage of information technology and improve product quality. The study indicated potential productivity gains in the order of 20% and potential savings in the materials costs of the same magnitude (F.R.I, 1993).

Even though the project itself was abandoned before it turned to full-scale experiments, consecutive programmes and studies have been strongly inspired by the Double Up work.

### **The Cluster Analysis**

In 1992 the Ministry for Industry launched a broad analysis of the entire Danish Industry divided into eight clusters inspired by Michael E. Porter's ideas as expressed in *The Competitiveness of Nations* (Porter, 1990). This study viewed for the first time Building and Domestic Housing as a whole, making manufacturers of building materials part of the industry. Up till then these industries had been considered part of 'manufacturing based on wood, metals or stone' respectively. It was recognised that the export from the sector by this definition was surprisingly high, a fact explained as a result of early and systematic industrialisation (Erhvervsfremme Styrelsen, 1993).

The analysis suggested a number of initiatives aiming at increased productivity and competitiveness nationally and internationally. Three specific programmes were recommended: First a systematic development of the building renovation process in order to reach the productivity level of new building – Project Renovation. Second a development of the product and process with a focus on better product quality and a higher productivity, based upon long term co-operation between leading firms within the industry – The PPB-programme. And third a long term, over all programme – Project House – to rethink the whole industry.

With minor modifications these recommendations became the guiding light for the following development.

### **Project Renovation**

The European preference for preserving and renovating older buildings instead of demolishing and reconstructing has introduced new needs for the development of the building sector productivity. This is the background for the Project Renovation, launched by the Ministry of Housing in 1995.

Project Renovation is a major effort comprising more than a hundred individual projects. It looks into a wide range of problems covering development of new components, new processes and new forms of co-operation as well as new management tools. Most of the projects comprise development combined with full scale testing in practice (Boligministeriet).

The programme is near its end and it can be observed that a wide range of new and very useful experience will be gained. However, the programme was fairly broad in its scope and the individual initiatives only little co-ordinated. Also the projects were selected on a competitive basis between ideas proposed by the industry with only a limited analysis of the needs. As projects and participants were selected on their creative merits mainly, lesser emphasis was put on how to transform the developed ideas into practise. At the end of the programme period this leaves a need for an extra effort to bring the results into daily use.

The broad scope with many participants has given the programme a very firm foundation within the industry, and through a very professional communication of the results, the programme has put focus on the need for developing the renovation sector under its own programmes. On the other hand, the many and very different ideas combined with a programme period of five years only, has on very few occasions made it possible to try out the ideas in more than one case. By the end of the programme it was recognised that short series of experiments for each idea might give rise to an unforeseen problem: Who will carry on the development and in particular make sure the results are implemented in practice? This very important issue of the 'ownership', as it was named, has become very much the focus in the latest Danish development efforts.

### **The Process and Product Development Programme**

The PPB-programme was initiated in 1994. It comprises four consortia consisting of at least an architect, a consulting engineer, a general contractor and a building society, that try out different strategies in developing a new approach to the building process. The target is mainly domestic housing but the results will be applicable to a wide range of projects.

The four consortia were selected through a competition where the participants' different approaches demonstrated the wide range of possibilities. One of the winning consortia proposed to try out a completely new building system based on steel and gypsum. One consortium went even more off the road proposing the usage of wood within domestic housing in buildings up to five floors. Unbelievable in Denmark where fire regulations up till then accepted wood in single dwelling houses up to two floors only. The remaining two consortia tried the same new approach to the organisation of the building process: they divided the task in accordance with building parts and systems instead of the usual division into trades. One of these groups reorganised the trades into 'process units' i.e. groups comprising all the skills – including design capabilities – required for the building part in question, f.i. the roof, the bathrooms or the heating system. The last group made the same division of the building but made contracts with existing manufacturers capable of supplying each of the subsystems in question under independent design, manufacture and install contracts. This approach is very much inspired by the Japanese car industry.

A common feature within the four consortia is vertical integration – i.e. partnering covering a number of projects. Also the development programs for all four consortia include integrated use of IT, efficient logistics in the supply of building materials and up to date quality assurance programs for work on the site (Erhvervsfremme Styrelsen 1995).

Even though the administration of social housing were transferred from the governmental agency to the local municipalities at the same time as the programme was launched, thereby hampering the market for the development, the programme is now well under way. By the middle of 1999 all four consortia have their first building projects completed and more under construction. The groups have all experienced more trouble than expected, but it seems that at least three consortia will complete their development in accordance with the over all schedule. However, all four consortia have learned that making the building process more efficient is a long haul effort. None of the groups have so far reached their productivity targets as they envisaged them at the start of their effort, but they have indeed opened roads to a higher efficiency. This shows once again that the introduction of a new approach or new building systems is very hard work, and it is doubtful whether more than one of the groups will benefit in the long run from the effort, if no further measures are taken. Initiatives to this end are discussed in the following section.

Also, all the groups have met difficulties in establishing a smooth co-operation because of the need for a changed behaviour by all the participants, a phenomenon often observed in partnering projects. In future programmes this problem should be envisaged and management involvement ensured from the very start in order to ease the problems in the day to day co-operation.

However, the PPB-programme has demonstrated the value of initiating a sequence of building projects over a number of years. This is of particular importance when the development involves a change in attitudes and a different behaviour by the participants, f.i. in a partnering arrangement.

### **Using the Manufacturing Industry's Methods in the Building Industry**

The Danish Academy of Technical Sciences – ATV – launched this study undertaken by a group of key persons from manufacturing industries and from companies within the building sector in 1997. Research in production methods at the technical universities was included in the work as well. The aim was to study to which extent the manufacturing industry's product development and manufacturing methods can be applied to the building sector.

In some ways this is the approach of the Lean Construction Initiative, but the study is broader in its scope as it also considers manufacturing of buildings as a product. And it looks into the market conditions and the surrounding legal and administrative frameworks as well.

The study does not go into depth of the matter. Its objective – like other ATV studies – is to outline potentials inspiring other to take over the ideas (ATV, 1999). The study report shows that a lot of inspiration can be found in the manufacturing industry methods. The systematic planning of product, process, the logistics, delivery and service which is characteristic of the modern industry can beneficially be introduced in the building sector. The same goes for the industry's practice of long term co-operation and redistribution of tasks in order to maximise the competitiveness.

The report recognises that such a transformation of the building sector can not be made solely by the sector itself, in particular not in a highly regulated market as the Danish. The client's behaviour must be changed as well and the legal framework surrounding building must be adjusted accordingly. The report presents a scenario for a 'marketplace' i.e. a procedure for choosing the supplier of a social housing scheme based upon a competition between a number of invited consortia. The process emphasises a new way of co-operation between client and supplier and makes other parameters than the offered price and product quality part of the selection of supplier. Past performance, process management and procedures are also important criteria.

Also the report opens a number of key issues and through its review of the expected customer and authority requirements to the house of the 21<sup>st</sup> century it clearly points to the need for a re-organisation of the building process based on industrialised components.

### **'Project House'**

Inspired by an earlier very successful development project: 'Project Ship' looking into the development potential within the traditional commercial vessel, the Danish Ministries of Trade and Housing in 1999 launched a similar project looking into the development potential within the housing sector (Boligministeriet 1998).

The project is still in a very early phase, but it has been recognised that there is a great difference between the manufacturing of vessels and that of houses. Also the structure of the industries as well as the business practices are different. It has therefore been decided to look more into the building process in general in this programme – where 'Project Ship' focused upon some critical features, particularly cost of operation of the ship of the future. The objective of 'Project House' is: *To produce double value for half the cost*. This is a very ambitious goal to set and probably most of the participants in the programme committee will be happy if only a fair proportion of the target is reached.

The general approach is heavily inspired by the industrialisation of the building process, which took place in Denmark after World War II (Bertelsen, 1997). It is to get the leading companies in the building sector to co-operate in the development of a higher productivity, using methods taken from the manufacturing industry as well as lessons learned from the recent years' development efforts within the sector itself.

A special focus within the programme is the needs of the customer. It has become evident that a potential increase in productivity is connected to a better fit to what the customers want and are ready to pay for. This puts the client into a key position within the programme as the representative for the coming users and as the critical buyer who can ask for and enforce an efficient production of his buildings.

### **Putting it all in perspective**

The Danish development effort over the last fifteen years seems to demonstrate the benefits derived from an alternation between analyses and experiments. But it also demonstrates the need for a long sequence of initiatives, and for the experiments to be stretched out for more than a few consecutive building projects.

The first experiments with Multi-storey Housing and the Development Quota were isolated projects where new methods were tested. Project Renovation was the first major programme that – loosely co-ordinated – put a number of players into action at the same time. The Double Up Study and the Cluster Analysis reviewed the results and put focus upon the importance of long-term co-operation and laid the groundwork for the following programmes.

The PPB programme had the adequate continuity but comprised fewer participants. The development efforts were co-ordinated and the programme's control system made the participants aware of their obligations to

develop. Finally the ATV study highlighted the results and in particular emphasised the importance of the client's participation as well as the inspiration to be found in the manufacturing industry.

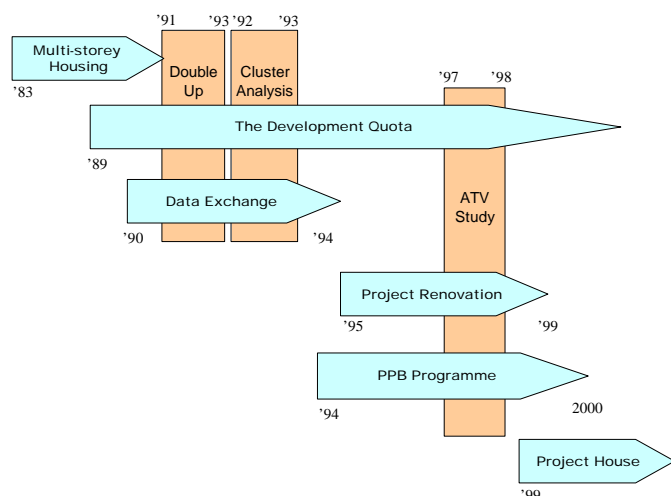


Figure 1 Programmes and analyses

understanding but that is probably the time frame one may expect when the objective is to change the industry behaviour.

## DEVELOPING THE BUILDING SECTOR

### Setting a Target

It is important to recognise that a fundamental change of the building sector with an aim to increasing productivity will call for a complete re-engineering of the industry to change its traditional behaviour. At the same time a significant number of customers must be asking for a changed delivery of its products. Also the framework guiding the sector must be changed accordingly. These pre-requisites will be dealt with in the following.

The actual choice of a national strategy is outside the scope of this paper. However, two different approaches seem possible when re-engineering construction as done within the PPB-programme. One is to industrialise the processes undertaken at the building site as tried out in the Building Logistics experiment and by one of the PPB-consortia. This strategy can be seen as an implementation of the lean construction principles (Howell and Ballard, 1998). The other is to look upon the building as a product to be manufactured and consequently making building an undertaking based mainly on prefabricated components, as tried out by another PPB-consortium. Both approaches have been investigated in praxis in the Danish development and as both seem to have their advantages, both should consequently be taken into serious consideration. The authors' expectation is indeed that the final outcome will be a mixture of the two.

However, it is of importance to stress the need for analyses before the start and during the process, particularly before the final strategy is chosen. These analyses shall highlight the needs and evaluate the results as well as concentrate the focus of the following development efforts trying the ideas in full scale.

### Firm but Flexible Programme Administration

The development of the building sector is a long haul. The Danish experience from almost fifteen years' effort shows that it is possible but also that an effort of less than ten years duration probably will not result in permanent changes.

On the other hand, one should not establish one comprehensive programme aiming at changing the whole sector but rather a long line of initiatives. Some of these may be more successful than others, some may even be considered fiascos while running, but must be seen as necessary mistakes in the global picture. However, it is important that all initiatives are based on all experiences gained up to their launching and that the evaluation of their results is based more upon the lessons learned than upon the expected results at the outset.

The programme administration must – jointly with the agents in the experiments – master the art of abandoning seemingly excellent ideas not working in practise, an art requiring deep understanding of the building sector's

It may seem that there has been too many and widely spread experiments, not only in their content but also in the way the programmes have been arranged. However, it is the authors' opinion that such a form is necessary when a whole but highly fragmented industry shall explore new ways of operating.

The upcoming Project House can be seen as the final block in this development process. Here a heavy involvement from a great proportion of the industry is expected, based upon the results from the previous fifteen years' experiments. It looks like all parties agree that a new approach must be made. It has taken fifteen years to reach this

nature. On the other hand, a lot of patience is needed. Ten to fifteen years to mature basically new ideas or to change the behaviour within the building sector is not a very long time.

Selection of the leading participants in the experiments is a matter of confidence, which can not be undertaken by promises or by traditional tendering only. Past performance – be it good or bad – is probably the most important parameter. If the programme conditions are so favourable as they need to be, the temptation to promise a lot to obtain the associated construction contract may be high, and penalty for not undertaking the experiment very hard to impose as the financial risks in the construction task itself are much higher. Therefore a skilled and competent day-to-day programme management is of great importance to keep the agents reasonably on track. But the programme administration must also, particularly when a programme comprises changing of the participants' behaviour, be flexible giving the participant leeway to navigate as they deem best, as long as they move towards the over all target in a manner fair to the programme intentions.

The Danish PPB-programme has introduced a formal control system of monitors *ie*, persons with expertise within building practise who are assigned to follow the development effort closely to make sure the process is kept on track, but also to advise the programme administration whenever change in scope is necessary. This system seems to work fairly well, particularly when division of responsibility between the management of the experiment's building projects and the monitor is clarified from the very beginning.

### **Establishing Ownership**

The very nature of the building sector and of its processes makes it mandatory for the programme administration to ensure ownership of results. By the term 'owner' we mean firms institutions or authorities who are willing and capable of integrating the results in their operation, thereby becoming the acting agents in the sector transformation. Without such owners the programme will probably give a lot of positive experience, but also frustrations because seemingly good ideas are not used after the programme termination.

One of the major players in the Danish renovation process is the publicly owned Copenhagen Renovation Society, which acts as administrator for a great number of renovations projects. They are as owner continuing the work of Project Renovation through their own 5 years' programme for the development of the productivity – the 'Toolbox'. The general idea is to develop and implement a new set of management tools, organisational and contractual arrangements as well as business procedures following the principles outlined above. This work will be undertaken in close co-operation with a number of their business partners as well as with the Danish Building Research Institute. It is foreseen that the main result in the first hand will be an increase in the contractors' earnings but it is envisaged that this later on will cause lower bids. Also better quality, shorter project duration and more reliable scheduling are expected outcomes.

### **Catching the results**

A special topic to consider is how to measure the effects, particularly the short-term results. Building projects are generally unique so where is the basis for comparison? In the longer perspective general indicators from the national economy will probably show any increase of the sector's productivity, but this may not be sufficient for the programme administration or indeed for the participants. To this should be added that measuring detailed production figures and particularly establishing formalised benchmarking systems in not a normal practise within the building sector.

As the key issue is to improve the productivity and quality on the construction site, and as construction managers are very busy people indeed, the measuring they have to undertake should be engineered to be directly beneficial to their day to day work, f.i. by highlighting the indicators of good or bad practise. It may be systematic reporting on the number type of change orders and unforeseen events. It may be weekly evaluations of the order or disorder on the site – to be presented to the workers, or it may be systematic measurement of the amount of waste removed from the site. Also the deviations from production plans tell a lot about efficiency. Even if such measurements do not comply in accuracy with demands from research, they put focus on the actual problems.

Other than that, more ambitious methods may be implemented as a supplementary source of information, but undertaken by a third party in order not to disturb the daily operations. In the Toolbox programme outlined previously, three levels of measurements have been identified: The operational level as outlined above, the intermediate level where the measurements result in reporting while the job is on hand, f.i. frequency studies and performance measurements for whole parts of the building, and the final level where measurements are based upon analyses of the actual costs as reported by the end of the project. San Martin and Formoso (1998) outlines

some more formalised methods, which may also be of interest to try out not only in individual projects, but integrated in wider programmes.

In any circumstance, a good piece of advice is to measure what can be measured, to count what can be counted, and to register the rest. This process in itself will give a lot of understanding of the nature of the problem.

### **Creating a Market Place for the Re-engineered Building Sector**

A fundamental change in the building sector behaviour must probably arise from a demand from the customers. The client must still require a high product quality but he must at the same time organise his procurement process to stimulate the formation of a desired new kind of co-operation and the new division of responsibility. To this end it is important to understand the mechanisms guiding the behaviour of the participants in the building process as dealt with briefly later in this paper and in detail by Thomassen (1999). Once a traditional design and build contract is won, the contractor's prime interest turns toward maximising his own profit, leading him to seek the lowest bids from the subcontractors, a behaviour which not necessarily leads to a better co-operation and definitely not to long term alliances. New contractual arrangements must therefore be developed to suit the local contractors and their actual capabilities, as well as the need for change and development of new qualifications.

It might seem peculiar that the client in this way has to interfere with the organisation of the process giving him his desired product. But as long as building is mainly a service industry, where the services are provided in a divided form, this has to be the case. As building becomes more and more based upon prefabricated components, this situation might change, but in today's market this is not the normal situation.

The Danish Association of Social Housing Agencies has decided to try out in practise the principles outlined in the ATV-study. Their idea is to invite the four consortia formed under the PPB-programme to participate on a new market place, where they gradually over a five year period will establish a true competitive procurement process based upon a product delivery by firmly established teams. Over this five year period not only the competition will be increased between the consortia, but the market place will also be opened up to further participants.

### **Changing the Frameworks**

The building process is highly complex. The reason for it not ending up in total chaos is probably the frameworks guiding the process and thereby making it less complex in practice.

Talking about frameworks, we do not mean only legal and technical rules. We also think of mental, cultural and habitually structures that guide us through incalculable possibilities and problems. These frameworks have emerged as the product of a long history where we learnt from experience and – often without knowing it – changed our behaviour accordingly. In stable periods, this framework is very beneficial, and we could probably not live without it. But in re-engineering it causes problems, because the process no longer corresponds with the problems the old frameworks reflect. We do not, and are not supposed to think of these guiding structures in our daily routines. Actually, we only discover them when we try to change them. But then we certainly come to recognise the shape and magnitude of the frameworks in which the building project is embedded. This is an area which has not been scientifically addressed in the described programmes and which needs more research.

It would be obvious to point to the *legal framework*. One important aspect of the ATV-study's proposal is that it allows competition on past performance and not only on quality and price. However, the tender regulations in Denmark and EEC are created in order to ensure price competition mainly. This makes it hard to replace one-off price competition with long-term relations based on collaboration. Also the rules for arbitration and for the correction of defects reflect the traditional trade-based building process. Probably this will also be the case in most countries having a legal framework guiding the tender process in construction.

*Administrative procedures* are another framework that may conflict with the new ideas, f.i. the rules guiding social housing projects in Denmark. Also the piece rate system hinders a re-organisation of the building industry. Firstly because the rates are based on previous experience. When doing things in a new way, none of the parties know how high, or how low, the rates should be. Secondly, piece rate payments are based on the idea of specialisation – i.e. the work is divided into clearly distinct operations. Integrated manufacturing changes this approach and thereby makes the piece rate system useless.

However, the main barrier seems to be *the way we think*. The barrier formed by this mental framework is so important that it is dealt with in its own subsection, but it deserves its own papers based upon its own research.

But the worst thing about the frameworks is probably not their magnitude or the need for changing them, but the need for *changing them all simultaneously*. If just one of the frameworks is still there, the new system will become dysfunctional, and the logical strategy from the individual party's point of view will be to go back to the old well-known ways, making the whole effort of re-engineering futile.

### **Developing a new culture**

Thomassen (1999) characterises the co-operation within building project as being captured in the Prisoners' Dilemma: All the other participants must co-operate loyally if it shall be beneficial for me to do it. If the others cheat, it is better for me to cheat as well. Within the complex nature of the building project this dilemma leads to a situation where co-operation is almost non-existent. This must be seen in the light that a great deal of the obvious methods for productivity improvement require an effort from other parties than the one getting the benefit.

Going from tough price competition between trades to long-term co-operation between manufacturers requires a completely new way of thinking throughout the industry. Even if all the participants are aware of being in a partnership, it is very tempting for the individual to give some assignments to outsiders that appear to offer lower prices. Such behaviour completely ignores the benefits of the partnership, but seems logical from the traditional price competition framework's point of view. Correspondingly, experience from another – not yet reported – Danish innovation programme shows that the sub-contractors do not grasp the possibilities of affecting their building process. They are so used to a situation where the final responsibility for the detailed design and for the process organisation belongs to the professionals.

As mentioned earlier, development in itself will not suffice, an 'owner' for the results must be found. In the manufacturing industry the owner is normally obvious, but this is not the case in the process oriented building industry. Also clients being used to interfering with the building process may find it hard to accept that they more and more are buying products and not processes.

All these practises are so well established in the culture of the industry, that the radical change needed will call for a deep change in the mindsets or for complete new players – probably for both. This is not an organisational barrier only but a mental one. Barlow (1998) questions whether the existing contractors in the building industry will be able to manage this change in the sector's behaviour and how this process can take place. He further wonders whether a better solution would be to stimulate the establishing of a completely new kind of firm, capable of managing the whole building process and putting the customer satisfaction clearly in focus?

### **CONCLUSION**

The Danish experience is that the development of the building sector productivity is possible but also difficult. It is basically a re-engineering effort calling for a change of behaviour, which must be undertaken as a long haul. Close co-operation between authorities, programme administration, owners, building research and industry itself is mandatory.

Further, it is recognised that

- The target must be clear and through the process narrowed in its focus to suit the local conditions. Also the programme administration must be firm in keeping the objectives, but flexible in their programme administration.
- The 'Owners' of the results – i.e. companies or clients authorities and institutes – who can and want to adopt the results and use them, must be identified and involved from the very beginning
- A number of competitive suppliers who are organised 'industrially' – i.e. organised in a way that allows 'organisational learning' – must exist
- A market must be established – i.e. buyers who understand the need to support the development by 'buying' untraditionally
- Business frameworks stimulating a changed behaviour must be ensured
- In the course of the development a simultaneous motivation and involvement of individual persons in all the acting 'companies' must be established
- A prolonged development process – i.e. more than 10 years – must be expected and the programme duration set accordingly, especially in connection with complex issues such as change of roles and processes.

## REFERENCES

Agapion, A, Clausen, L, Flanagan, R, Norman, G and Notman, D (1998), *The Role of Logistics in the materials Flow Control Process*. Construction Management and Economics vol. 16, No 2, 1998.

ATV (1999), *Byggeriet i det 21. århundrede – industriel reorganisering af byggeprocessen*. ('The Building Industry in the 21<sup>st</sup> Century – Industrialised Re-organisation of the Building Process', In Danish with an English summary). The Danish Academy for Technical Sciences.

Ballard, G and Howell, G (1998), *What Kind of Production is Construction*. 6<sup>th</sup> International Conference on Lean Construction, Guarujá, Brazil.

Barlow, J (1998), *From Craft Production to Mass Customisation? Customer-Focused Approaches to Housebuilding*. 6<sup>th</sup> International Conference on Lean Construction, Guarujá, Brazil.

Bertelsen, S and Nielsen, J (1997), *Just-In-Time Logistics in the Supply of Building Materials*. 1<sup>st</sup> International Conference on Construction Industry Development, Singapore.

Bertelsen, S (1997), *Bellahøj, Ballerup og Brøndby Strand – 25 år der industrialiserede byggeriet*. ('Bellahøj, Ballerup og Brøndby Strand – 25 years Industrialising Building'. In Danish). Danish Building Research Institute.

Boligministeriet (1994), *Udvikling af etageboligbyggeriet*. ('Re-development of the Multi-storey Housing'. In Danish). Danish Ministry of Housing and Urban Affairs.

Boligministeriet (undated), *Project Renovatin – 62 abstracts*. Danish Ministry of Housing and Urban Affairs.

Boligministeriet (1998) *Projekt Hus – et udviklingsprogram til et spring fremad i dansk byggeri*' ('Project house – a Development Programme for a Leap Forward in Danish Construction'. In Danish). Danish Ministry of Housing and Urban Affairs.

Erhvervsfremme Styrelsen (1993), *Bygge/bolig – en erhvervsøkonomisk analyse*. ('Building and Domestic Housing – an economic analysis'. In Danish). Danish Agency for Industry Development.

Erhvervsfremme Styrelsen (1995), *Process and product development in the building industry – a Danish development programme*. Danish Agency for Industry Development.

F.R.I (1991), *Dobbelt Op – Perspektivplan for dansk byggeri*. ('Double Up – An Outlook for the Danish Building Sector'. In Danish). Danish Association of Consulting Engineers.

F.R.I (1993), *Synergier og barrierer i byggeriet – på sporet af den tabte produktivitet*. ('Synergies and Barriers Within the Building Sector – on track of lost productivity'. In Danish). Danish Association of Consulting Engineers.

Nilesen, J and Bertelsen, S (1997), *Innovation Through Collaboration*, 1<sup>st</sup> International Conference on Construction Industry Development, Singapore 1997

Nissen, H (1972), *Industrialised Building and Modular Design*. The Cement and Concrete Association, London.

Porter, M (1990), *The Competitive Advantage of Nations*. The Macmillian Press, London

San Martin, AP and Formoso, CT (1998) *Evaluating Building Systems Based on Production Process Management and Lean Construction Concepts*. 6<sup>th</sup> International Conference on Lean Construction, Guarujá, Brazil.

Thomassen, MA (1999), *Escaping the Prisoner's Dilemma – Trust and Mistrust When Reengineering the Danish Building Sector*. International Conference on Construction Process Re-engineering, Sydney.