LOGISTICS: A STEP TOWARDS LEAN CONSTRUCTION

Jean-Luc Salagnac[1] and Madjid Yacine[2]

ABSTRACT

Some factors are likely to impel a deep change in the construction industry in France. As in other European countries, this activity remains traditional in spite of a significant flow of innovations concerning both industrial products and execution of works on site.

Experimental building operations have been carried out within the frame of a national five year programme focused on the improvement of the activity on site. The consequences of these experiments on the relations between actors have been studied from different points of view. Nearly one hundred operations will have been supported by the end of 1999.

This paper is based on the evaluation of several of these experimental operations with a special emphasis on site logistics, which is considered as a step towards lean construction, because it clearly reveals where are the limitations to improvements.

The variety of projects, of size of contracting companies, and of constraints of industrial products involved in these experiments allow concluding remarks concerning the conditions of development of lean construction in France

KEY WORDS

Logistics, lean construction, quality, transport.

[1] Head of project "Site and Industry" at the Centre Scientifique et Technique du Bâtiment, 4 avenue du recteur Poincaré, 75782 PARIS Cedex, France, +33 (1) 40 50 28 39, fax: +33 (1) 40 50 29 10, salagnac@cstb.fr

[2] Is preparing a PhD on the development of logistics in construction at the Ecole Nationale des Ponts et Chaussées and is presently responsible for studies at the transport and logistics engineering company EUROSIRIS, 60/62 rue d'Hauteville, 75010, PARIS, +33 (1) 44 79 91 41, fax : +33 (1) 47 70 11 93, eosiris@mhnet.fr

INTRODUCTION

The evolution of the markets and the satisfying fast changing demands has led industrialists to deeply change the organisation of their production during the last decades.

Regarding this general observation, construction is in a contradictory situation. On one hand, construction activity requires a high degree of flexibility of actors who are involved in a building operation. On the other hand, the organisation of the construction process remains very traditional, from the early design stage to the late utilization phase of the building.

Whilst manufacturers were discovering the merits of just in time delivery (a concept that has been familiar to construction industry people for many years in terms of the delivery of ready mix concrete to site), they were also able to develop new types of production management to cope with the above mentioned challenges.

The automotive industry is a well- known example of such an evolution. Moving from mass to client-customised production, these industries have developed new kinds of management, including lean production. As a result, they can manage batch productions and react quickly to fluctuating demand.

The claim is to be able to produce a product that is exactly adapted to the customer's demand. This is of course never completely true: we speak of industry, not of production of unique items made by craftsmen. The cost of these customised products must be low enough for a large number of clients to afford.

The marketing forces help convince the client that he buys a product especially made for himself, but it remains an industrial product, benefiting from industrial production.

Could the construction industry benefit from these developments taking place in the manufacturing industry? How could it happen? What changes would it bring? Where would evolutions be the most necessary? Who are the actors able to impel such evolutions? Which are the limitations to these changes? Which are the different actions that contribute to the development of lean construction?

This article intends to present some facets of the answers to these questions in the French context, with some openings on the European context. Logistics will be especially emphasised as a key aspect.

MAIN FEATURES OF THE FRENCH CONSTRUCTION INDUSTRY

Such an exploration requires the presentation of the major characteristics of the construction sector in France and particularly the main technical choices, which have a great influence on the potential of evolution.

ACTIVITY

The total 1997 French construction turnover was 87 billions Euros[3]: 67 billions Euros for building (dwellings, offices, commercial, agricultural, etc..), 20 billions Euros for civil engineering. The exportation activity is another 13 billions Euros.

One major feature of the building sector is that a bit more than half of the money comes from works on existing buildings (renewal, refurbishment). The other part concerns the construction of new buildings, the most important part of which is dwellings (58%). The average size of these operations is twenty to thirty dwellings (It was more than ten times more in the 60s). Individual houses represent about two third of the total dwelling market.

TECHNIQUES

The main techniques commonly used to build these buildings are rooted both in tradition and in history. This is particularly true for the main frame erection techniques.

For small buildings (i.e. individual houses) masonry (both concrete blocks and bricks) represents about 70% of the market. For larger buildings (i.e. multi-story), in situ poured concrete is the most common technique. The reason for this is probably that reinforced concrete was originally developed in France at the end of the 19th century and that this technique was very popular during the post war period. A unique set of industrialists (concrete forms, concrete producers, crane manufacturers) and of contractors was developed at that time. The importance of this effect remains in the present time.

In spite of a very favourable period and of State funded programmes, industrialised construction is no longer widely used. The industrial tool developed during the 60s and 70s is now reduced to a very weak part, but for some very specific products . The predominance of concrete is such, that other materials (e.g., wood and steel) represent a small part of the total market, especially on the housing market (about 5% for wood, less than 5% for steel).

Concerning other techniques and products used to erect buildings, plaster board is very popular for partition walls. Inner insulation is the main technique (outside insulation is rather confidential), plastic windows represent roughly 45% of the market, tiled roofing is a major technique for all buildings, fluid networking remains traditional and is consistent with the main frame technique.

The structure of the contracting companies is also very close to the market structure. Besides five construction groups with an international size that represent 7% of the total building sector turnover, a bit more than 260,000 small enterprises (less than 50 people) represent 72% of the same market. The remaining 21% comes from the activity of medium size companies (up to 200 people), some of which are subsidiaries of the big five.

This very fast overview of building construction techniques in France shows that the French construction system is very fragmented between a great number of actors. This is not a national peculiarity, as this situation is encountered in other European countries.

---

[3] 1 Euro ≈ 1 US Dollar

The predominance of concrete over any other main frame technique is probably a more important specificity. Together with the important role played by the State on the construction market, these are some of the leading factors influencing future evolution.

TRANSPORT FLOWS FOR CONSTRUCTION

In 1997, transport flows of products and materials dedicated to construction in France represented 872.1 million tonnes (about 45% of the total freight), or 35.5 billion tonne-kilometres (16% of the total).

This means that these goods travel short distances (41 km on an average). The higher the added value of the product, the longer the distance of transportation. More than 95% of these flows are transported by road with a geographical distribution depending on the economical activity of the regions.

From these considerations, it may be concluded that the most important flows are concentrated in the vicinity of construction sites. The site is in fact the concentration point of all goods that are assembled or transformed to erect the building. The co-ordination of these flows is of the utmost importance in order to achieve the goal of lean construction. This might be considered as obvious for somebody outside of the construction business. In fact, this is a very difficult problem to be solved, especially for "ordinary" operations as we shall describe later.

EXPERIMENTAL OPERATIONS AND THEIR CONTEXT

A very interesting context exists in France for the segment of low rent dwellings. For such operations, four to five years thematic research and experimentation programmes are supported by the Ministry of Construction. A national organisation (Plan Urbanisme Construction et Architecture: PUCA), created in the 70s, manages several of such programmes dealing with a wide variety of domains, from sociological to technical and organisational subjects. One of these programme, named "Chantier 2000" ("Site 2000"), deals with some aspects of lean construction.

With about hundred operations, a wide variety of experimentation has been carried out, or are still ongoing, since 1995. These experimental operations are selected from call for tenders addressed to teams that may associate building owners, industrialists, architects, contractors, and laboratories. The selected operations then become the support of the experimentation, which is assessed by an independent body. Most of these experimental operations concerning lean construction have a focused interest on logistics. This is the reason why this article emphasises this aspect.

These experiments allow a wide variety of problems to be considered under different contractual situations (general contractor, distinct contractors with different co-ordination possibilities). For instance, different scenarios of relations between the providers and the site have been tested. They may concern the ways the needs on the site are analysed with respect to the peculiarities of the project. From this phase, delivery planning, product packaging, identification and control of product flows by means of suitable information are all

experimented with. Some experiments may concentrate on the main frame erection phase, others on the following phases.

This gives a very rich set of experiments that are systematically evaluated. The results are discussed during symposiums. Some transverse analyses are also performed in order to study the impact of the impelled changes on the organisation of actors.

Construction logistics has then been particularly discussed in the main contractors and in the SME contexts.

LOGISTICS ON A DAILY BASIS

In an ideal organisation, all goods delivered on site should be the right ones, should arrive at the right time and should be placed at the right location, in order to be transformed or assembled at the right place on the site.

IDEAL SITUATION

Such an ideal system can be approached in factories, as visits by most of the industrialists producing goods for construction can prove it. One very pedagogic example is given by the production of plastic windows.

For a given operation, information coming from the design stage is transmitted automatically to the production line where plastic profiles are brought, cut, tagged and processed in order to create the right frames at the end of the line. Window panes are then assembled on the frames. These panes are stocked on supports in such an order, that the pane on the top of the stock is the one that is needed for the frame that has just been produced.

Some manual operations are necessary to finish the product, and the brand new plastic window can be loaded on a pallet. On each window, tags are stuck with full address of the site, identification code referring to the location of the window in the future building and other information. In some cases, this information is printed on the tags in order to be "man processed" and/or "computer processed". With such an organisation, the workers on site should receive the right windows in the right order (and just in time).

This is unfortunately not the case. They normally receive the expected windows, but the way the production is rationalised in a factory differs from the way it is understood from the site. The factory has rationalised its production taking into account the complete production chain, including the last link, i.e. the transport. In order to minimise transportation costs, the load of the lorry must be optimised. Window frames must be sorted by size, the weight must be distributed among pallets, other technical considerations must be taken into consideration (for instance when the window has an integrated rolling shutter).

At a given moment, the windows produced in the factory are to be delivered for, say, 30 to 40 different sites located at very different places. It is then very difficult to satisfy the demand of a given site that wishes to receive the windows in a predetermined order. This was tried during one of the experimental operations. The over cost was 30% compared to the normal situation. This was due to more transportation with partly loaded trucks. On the other hand, workers were very satisfied because they had no hesitation in the identification of windows that were separately packed with clear attached information. They gained time and

money because they were paid according to the number of windows assembled to the main frame of the building.

In spite of this economical counter-performance, it must be underlined that the common situation in France for plastic windows is that the companies integrate both the production in the factory and the assembly of the products on site. Such an experiment would have been more difficult with other products because of the existence of two separate actors: the industrialist and the contractor.

Nevertheless, logistics organisation approaches were also tried in such situations.

ORDINARY SITUATIONS

For nearly all other products, the on sites delivery process requires the action of two main participants: the industrialist who provides construction goods either directly to site or through a distribution network, and the contractor, who is responsible for the assembly of these goods with the other parts of the building.

Each of these actors is immersed in its own organisation. If we consider these two actors are inserted in a global construction logistics process, it becomes clear that the only place where they can co-operate is the construction site.

This emphasises the role of the delivery process. It is the moment when products are transferred from the manufacturer to the contractor. Any inadequacy in this process (delay, packaging, conformity, etc.) will consequently generate extra-costs. The co-ordination of both upstream and downstream information is of the utmost importance to create the conditions for an optimised delivery process.

The contractor generally orders from the industrialist products, which are in conformity with the specifications of the project. The way these products are stacked by the industrialist is rarely discussed between him (or his distributor) and the contractor. The general situation is that products are delivered on site in sub-optimal conditions.

The moment when the delivery occurs has often been fixed directly between the contractor and the industrialist (or his distributor), but this information is rarely precisely transmitted to the other actors of the project. The representative of the contractor may be present or not when goods are delivered on site, and the products are placed where room is available. Very often these products are handled from these places to their final destination in unsatisfactory conditions. When the tower crane of the main frame builder is available, “solutions “ can be defined. If not, other solutions have to be found.

Industrial products can be damaged and the final quality of the building will suffer from this situation. The lack of co-ordination depends of course on the size of the operation and of the potential of organisation of the contractors and of the construction team. But, even with fairly well organised construction teams, the situation is far from ideal.

In order to improve ordinary practices, one of the experimental operations involving small size contracting companies, consisted of asking the contractor to value the cost of the handling of products. The idea was to define a service on site that would consist of handling the products for the benefit of the contractors. This generous idea happened to be an anti-economical one, because the offers of these contractors were abnormally high: they never

identify these handling costs in their bids and do not know precisely how much it costs. The promoters of this idea had just forgotten that the handling function cannot be separated from the whole work process. Logistics cannot be a clearly identified function of these contracting companies because it is integrated in their own process. The part of the logistics that is at the interface between contractors is then ignored.

For larger companies, belonging for instance to the majors construction groups, the situation is different but still not ideal. These companies effectively manage the erection of the main frame, especially when it is concrete poured in concrete forms. This concrete is very often delivered by concrete mix providers who also manage just in time delivery.

For these sites, the tower crane is the true "conductor" of the process. She gives the tempo of the operations. The actions of some other contractors (mainly the electrician and the plumber) are also often well managed because of the strong interface with the main frame erection process.

When other works are considered (partition wall, windows, HVAC for instance) the quality of the logistics context decreases. The companies that have to act in these domains are often chosen very late. It is then difficult to anticipate their needs in terms of storage areas, paths for the handling of products, manipulation equipment.

Among the potential research that such companies have identified, the development of a very precise planing tool is ranked with a high priority for the future. Such a tool would allow the anticipation of actions (especially, but not only actions related to the delivery of goods to the site) and would make the construction process smoother and probably more efficient.

SEQUENTIAL ORGANISATION

Logistics organisation on construction sites cannot obviously be introduced without an evolution of the way the works are executed. Traditional methods are inherited from a time when the different corporations (mason, carpenter, plumber, etc…) worked one after the other. Each of these actors had to adapt his work according to what the previous actor had done.

As far as industrial products are used and because of severe time constraints, it is very important that the work organisation on the site fits with the capacity of fast and precise product delivery.

One of the answers that has been experimented is the so called "sequential organisation." The idea is to organise a transfer of tasks between contractors (workers) in order to have them executing consistent sets of tasks corresponding to precise parts of the building. These parts generally correspond to main functions of the building, i.e. structure, air and water tightness, inner partition, painting, etc.

In a sequential organisation, the "plasterer" will for instance build partition walls and will also include, during the same "sequence", electric wires in the walls. Compared with a traditional organisation, this part of the building will then be made by only one contractor, instead of two (plasterer, electrician). The content of the work will change as well as the responsibilities.

The potential advantage of such an organisation in a lean construction perspective is two-fold. First, the "sequences" of work correspond to a functional approach of the building production design instead of the traditional specialised skills approach. It may be expected that a more precise definition of tasks can be made including interfaces between traditional tasks. The control of delays due to these interfaces problems can be better managed and the planning should be easier to define precisely and to respect.

Second, the goods necessary for the contractor in charge of a given sequence can be precisely detailed, and the products delivery planned. The providers of these goods can then better anticipate their actions and bring added value through services for the benefit of the contractors (packaging, information management, handling equipment).

Such an organisation requires a more important co-ordination of all the actors than is traditional. The designer, the contractor(s) and the provider(s) are particularly concerned. The logistics functions, gathered in a logistics "domain", then appear as shown on Figure 1.

These functions ensure the links between a well-anticipated organisation of works on site with regard to the project specificity and to the provider organisation capacity. This latter actor could be the manager of a platform where all the goods needed for a given sequence could be stored, packed according to predefined specifications determined by the site.

In spite of this interest, there is a great difficulty in introducing such a change, because of the inertia of the actors and because such transfers of tasks also means transfers of money. The building owner can impel such evolutions when he is convinced he gets better quality for the same money.

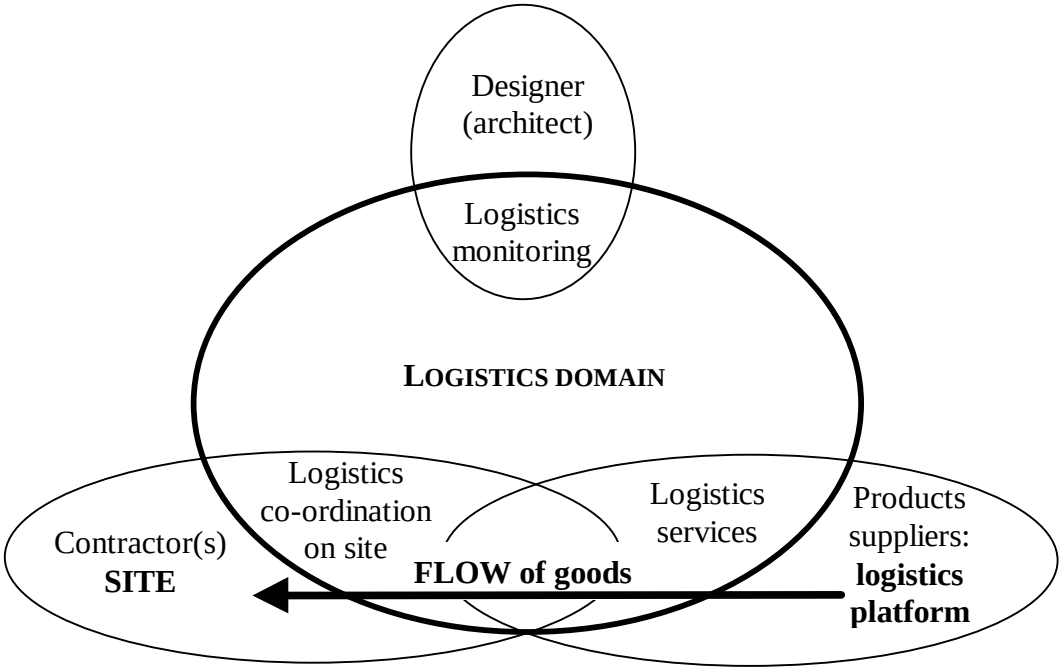

Figure 1: The Logistics Domain

Within the logistics domain, a strong co-ordination, by means of information exchange, between execution of work, logistics monitoring and supply, results in a flow of goods adjusted to the needs of the site according to the sequential organisation.

SOME TEACHINGS

In the context of this short paper, the above presentation of common and experimental situations on building construction sites in France is necessarily limited, and the contrasts are probably too stiff. Reality is a bit more complex, but we have emphasised the main characteristics of daily situations. We have also tried to identify points that make the development of logistics difficult. An analysis of these points provides some teachings that are the basis for future improvement actions.

DIFFICULTIES IN ANTICIPATING CO-OPERATION

One of the features of lean construction (production) is the necessity to create the conditions of "good" co-operation between actors, wherever they are in the process from the early customer demand to the late exploitation phase

Comparison with other industrial activities (eg automotive industry) is often made to conclude that construction has a great potential of improvement. This is not false, but, whatever is the considered reference activity, there is always a leader in the process, who is in a position to define the specifications of the renewed process likely to meet the objective of lean production.

It is unfortunately not true in construction, at least in the French context. The building owner, or the promoter of the operation, should be this leading actor, but he is not in reality. The legal separation between the design stage and the construction stage is often mentioned as the explanation to this situation. For very good reasons, the law has ordered these rules, but they hinder full co-operation.

If these rules were revised , would it be better? The answer is not necessarily positive. Private operations can be organised outside of these rules. For instance, design and build procedures can be adopted in such a context. Anticipation of the different phases of the building life is then likely to be more efficient, but basic economical arguments may be stronger than the expected potential advantages.

It is definitely true that the higher the economical pressure, the lower the price of a given work. A good way to raise and maintain the economical pressure on the actors is to select them as late as possible. This is controversial within the aims of a lean organisation.

PROBLEM OF PERFORMANCE MEASUREMENT

Some experimental operations have shown that workers on site have taken benefits of better organised delivery processes. No time is wasted looking for the right product in a stack, no error in the choice and subsequently no need to correct the consequences of a mistake (additional handling for instance). A better space organisation with limited risks. A better building quality for the end user and the exploitation teams.

All the concerned actors will be able to evaluate the direct costs of a specific attempt to improve the organisation. More space, more pallets, more transport, more efforts to prepare the work.

How can the resulting better work conditions be valued? How can the risk reduction be valued? How can the better quality be valued? These questions can be approached by means of statistics for the global construction activity. Is it possible to value these progresses on a single site in order to motivate the different actors? Probably not.

The balance between the direct expenses and the expected benefits is very difficult to define. The characteristic times of these two terms are strongly different. Direct costs have to be paid before the end of the operation: this is a short period process. The expected benefits are likely to be valued much later this is a long period process. Involved actors on a site may not wish to invest immediately for potential long term benefits.

CONCLUSIONS

For cultural and historical reasons, there are many differences between the northern and the southern countries in Europe. These differences can be observed on the many occasions when one travels through these countries. One of the clear indicators is construction, especially buildings. When looking at existing buildings or at buildings being erected, we can guess the deepness of the roots between technical choices, production organisation, available materials, local climate, culture and many other social features.

The development of lean construction cannot ignore this reality. The results of the experimental operations we have briefly presented cannot be analysed without taking the French context into account. The same experiment could have been more or less successful in another European country. Some of the organisations and techniques that have been trialled in France are daily practices in some of these countries. French daily practices may be ignored in these countries and could be considered as innovations by local builders.

Lean construction consists of a search for consistency between the industrial activity and the site activity for the benefit of the building user. There are probably different ways to reach such a goal. Exchange of experiences is very important.

Evolutions in our industry are slow. More precisely, they have always been very slow. Some reasons for a quicker change may be expected in the near future. This hypothesis is based on signs that have been becoming stronger for about a decade:

- growing interest for environmental problems will undoubtedly have consequences on the way buildings will be designed, erected and maintained.
- concentration (at a European and, in some cases, at a world level) of manufacturers providing the building industry and of product distributors is likely to change the traditional relations between actors.
- development of consumerism concerning buildings (new and existing) will probably influence the design of products.

On the other hand, some other factors must also be taken into consideration:

- new buildings construction has come to a stagnant level and works (repair, maintenance, refurbishment) on existing buildings is more than half of the total market.
- main construction groups (the big five) have clearly recently indicated their intention to withdraw from the building market which is no longer sufficiently profitable , compared to other construction business (urban and civil engineering for instance).

ACKNOWLEDGEMENTS

This article is mainly based on the evaluations of some tenth of experimental operations that have been selected and supported by the French Plan Urbanisme Construction et Architecture. Authors have directly been involved both in the evaluation process and as researchers for some other experimental operations.

REFERENCES

Evaluation and research reports are regularly published by the PUCA. These reports and other related documents are accessible from July 1st, 1999 on the web site: www.chantier.net.

Aiello R. et al. (1997). *Pour une logistique des chantiers (recherche PCARD)*. PARIS, Plan Construction et Architecture, May.

Aiello R., Bardou M., Colas R., Colombard-Prout M., Doucet J-M., Gobin C., Labarre J-C, Laburthe J-C, Le Meur O., Roland, O. (1997). *Development of site logistics (research carried out by the main French construction companies)*. PARIS, Plan Construction et Architecture, May.

Blondot P., Chambaud R., Gibert M.(1997). *De la conception à la logistique*: *Rex PORTES-LES-VALENCE*. PARIS, Plan Construction et Architecture, May.

Blondot P., Chambaud R., Gibert M.(1997). *Building design and logistics organisation: Rex*[4] *PORTES-LES-VALENCE*. PARIS, Plan Construction et Architecture, May.

Courbe G. (1997). *Séquentiel et logistique avec des entreprises artisanales*: *Rex PLONEIS ET GUENGAT*. PARIS, Plan Construction et Architecture, May.

Courbe G. (1997). *Sequential organisation and logistics for small size construction companies: Rex PLONEIS ET GUENGAT*.- PARIS, Plan Construction et Architecture, May.

Gibert, M. (1997). *Logistique de chantier: du gros œuvre aux corps d'état secondaires*: *Rex SAINT CHAMOND*. PARIS, Plan Construction et Architecture, Jan.

Gibert, M. (1997). *Site logistics: from main frame to finishing works: Rex SAINT CHAMON*D.-PARIS, Plan Construction et Architecture, Jan.

Guffond J-L, Leconte G.(1999). *Logistique et ingénierie de production.* PARIS, Plan Urbanisme Construction et Architecture, Apr.

---

[4] « Rex » stands for experimental operation

Guffond J-L, Leconte G. (1999). *Logistics and production engineering (synthesis of a workshop based on Rex case studies)* - PARIS, Plan Urbanisme[5] Construction et Architecture, Apr.

Martin P. (1998). *Logistique service*: *Rex PANTIN*.- PARIS, Plan Urbanisme Construction et Architecture, Nov.

Martin P. (1998). *Logistics service (development of new services on site): Rex PANTIN*.- PARIS, Plan Urbanisme Construction et Architecture, Nov.

Martin P. (1997). *Séquentiel et logistique en ossature mixte acier-béton*: *Rex GIERES*.- PARIS, Plan Construction et Architecture, Jan.

Martin P. (1997). *Sequential organisation and logistics in the case of a steel and concrete building frame: Rex GIERES*.- PARIS, Plan Construction et Architecture, Jan.

Martin P., Salagnac J-L. (1999). *PME et logistique* .- PARIS, Plan Urbanisme Construction et Architecture, Apr.

Martin P., Salagnac J-L. (1999). *Logistics and SMEs (synthesis of a workshop based on Rex case studies)*.- PARIS, Plan Urbanisme Construction et Architecture, Apr.

Salagnac J-L. (1999). *Code chantier: Rex LA FLECHE*.- PARIS, Cahiers du CSTB, n° 3145, Jul – Aug.

Salagnac J-L. (1999). *Site code (assignment of information to products delivered on site): Rex LA FLECHE*.- PARIS, Cahiers du CSTB, n° 3145, Jul – Aug.

Salagnac J-L. (1998). *Logistique et approvisionnements*: *Rex VALENCE*.- PARIS, Cahiers du CSTB, n° 3079, Nov.

Salagnac J-L. (1998). *Logistics and products delivery: Rex VALENCE*.- PARIS, Cahiers du CSTB, n° 3079, Nov.

Yacine M. (1997). *Optimisation de la gestion des flux des matériaux de chantier*.- PARIS, Plan Construction et Architecture, Sept.

Yacine M. (1997). *Optimisation of the management of products flows on site* - PARIS, Plan Construction et Architecture, Sept.

[5] Plan Construction et Architecture became Plan Construction Urbanisme et Architecture in 1998