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Why is Design Delivery always Behind Schedule? A Critical Review of the Design Planning Techniques Adopted for Real Estate Projects in São Paulo - Brazil.

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ABSTRACT

When talking about building construction, the accomplishment of stated schedules is a constant problem; therefore, there is a constant developers' claim about design delivery being late. The design process is informally managed, with inappropriate planning techniques and low utilization of Information Technology resources. Based on these justifications, the first author's Master Research was developed, in order to study the design process planning and to come up with ways of improving its efficacy. The Design Structure Matrix (DSM) has been applied in the research like a System Analysis tool, because it provides a compact and clear representation of a complex system and a capture method for the interactions, interdependencies and interfaces between system elements, and also as a Design Management tool, because it provides a design representation that allows for feedback and cyclic task dependencies. This paper introduces the mains conclusions of this research: a diagnosis of the problems that are the main obstacles to efficacy improvement of the design building planning and recommendations to all the agents involved, aiming to overcome the obstacles mentioned.

KEYWORDS: design planning, design process, concurrent design, design management, design structure matrix.

1. INTRODUCTION

It is possible to enumerate several justifications for studying design process planning. These justifications are found mainly in the limitations of the usual hiring and project management practices, in the project coordinators' ignorance about the adequate management tools and about the mechanisms to generate design information flow; in the organizational deficiencies of the design companies and in the insufficiency of academic research developed on the theme, just to mention some of the justifications that make the subject relevant.

In the real estate market, meeting deadlines and schedules is a recurrent problem, since, as a rule, the major complaint by the hiring parts is that projects are delayed.

It can be said that the current project management and planning practices are most of the time restricted to the mere contract control and design delivery.

The usual planning tools are bar diagrams. They are limited tools, as they simply graphically represent the stages of these contracts, and do not take design complexity into consideration, a process of great interactivity and intense information exchange.

2. RESEARCH METHODOLOGY

For developing the research, a case study and a bibliographic research were conducted. A topic that was markedly noticed in the bibliographic research, for being an important technique and studied by most researchers on the subject, was Design Structure Matrix or DSM., as it is better known (Austin, S. 1999); (Browning, T.R., 1998); (Cho, S.H., 2001); Manzione, L., 2006).

At the case study stage, the intention was to know the scenario of a company acting in the real estate market, in which the development of the executive project of a residential building was followed up. One of the main points of this stage was the study of the planning model adopted by the company, as it was noticed that part of the efficacy problems observed are due to inadequacies of the model for the different practical situations experienced in the project.

3. CASE STUDY

A case study was conducted in a Contractor and Development company in the city of São Paulo, and in four design companies working for it.

This study was conducted between June, 2005 and March, 2006, and consisted in following up a typical project of the company. This follow-up was conducted from the pre-executive projects stage up to the executive and detailing projects, and aimed at learning about the Design Planning

Process by analyzing and observing the management practices adopted by the company.

The planning strategy adopted by the company consists in dividing the project schedule into two parts. The first, concerning the activities that occur in the standard floors; and the second, concerning the activities in the atypical floors.

The company adopts a standard schedule for these two project stages, with a total duration of 150 days, being 112 days for the standard storey, and 150 days for the atypical floors.

The company organizes the activities and the project deadlines for the standard floors according to the schedule represented in **Figure 1**.

The model adopted, though having a reasonable number of activities (50), does not detail the activities at the lower levels of the project hierarchy, which hinders the survey of sources and of the necessary information for meeting the tasks. The activities are presented as “black boxes”, showing that the model was elaborated with greater emphasis on the designers contract control than on the production of the necessary parameters and solutions for developing the project.

The almost exclusive predominance of this vision, which was applied in the construction of the model adopted, greatly limits the planning efficacy, as it fails to focus on obtaining information along the process, and only controls the delivery of the stages.

The project management method adopted by the company also imposes a large number of revision, control and critical analysis activities that imply the creation of activities denominated “revised emission” for their fulfillment.

These are activities that involve rework and imply new revision cycles until they manage to meet the verification requirements.

	Task name	Duration
1	**STANDARD FLOOR**	**112 days**
2	**Pre-Executive - STANDARD FLOOR**	**19 days**
3	**Architecture**	**5 days**
4	Standard floor plan section /standard variations	3 days
5	Contractor verification and axel marking	2 days
6	**Structure**	**4 days**
7	Standard mold/ stairway mold and section	2 days
8	Contractor verification	2 days
9	**Revised emission**	**6 days**
10	Architecture	2 days
11	Structure	2 days
12	**Sealings**	**4 days**
13	Horizontal dim. and modulation/ wads/ frames	3 days
14	Contractor verification	1 day
15	**Revised emission**	**5 days**
16	**Architecture**	**2 days**
17	Standard floor plan	2 days
18	**Structure**	**2 days**
19	Standard mold	2 days
20	Critical analysis and approval – revised emission	2 days
21	**EXECUTIVE – STANDARD STOREY**	**93 days**
22	**Fittings**	**40 days**
23	Standard storey electrical fittings	10 days
24	Standard storey hydraulic fittings	10 days
25	Standard storey pressurization and ventilation	10 days
26	Contractor verification – fittings	5 days
27	**Final emission - fittings**	**15 days**
28	Standard storey electrical fittings – plan options	3 days
29	Standard storey hydraulic fittings	3 days
30	Standard storey pressurization and ventilation	3 days
31	Hydraulic and electrical: perforation	5 days
32	Contractor verification - fittings	5 days
33	Standard storey electrical fittings and revised plan	2 days
34	Revised standard storey hydraulic fittings	2 days
35	Revised standard storey pressurization and ventila	2 days
36	Hydraulic and electrical: revised perforation	2 days
37	Contractor – electrical mini plans for clients	10 days
38	**Architecture**	**5 days**
39	Final emission – part axles, parapet, etc.	3 days
40	Contractor critical analysis and approval	2 days
41	**Structure**	**21 days**
42	Revised emissions with delayed allotments	3 days
43	Contractor critical analysis and approval	2 days
44	Final emission – with perforations – standard and var	5 days
45	Contractor critical analysis and approval liberating co	1 day
46	Standard strengthening	10 days
45	Contractor critical analysis and approval liberating co	1 day
46	Standard strengthening	10 days
47	**Sealings**	**65 days**
48	Plans and elevations	35 days
49	Contractor Verification	15 days
50	Contractor Verification	15 days

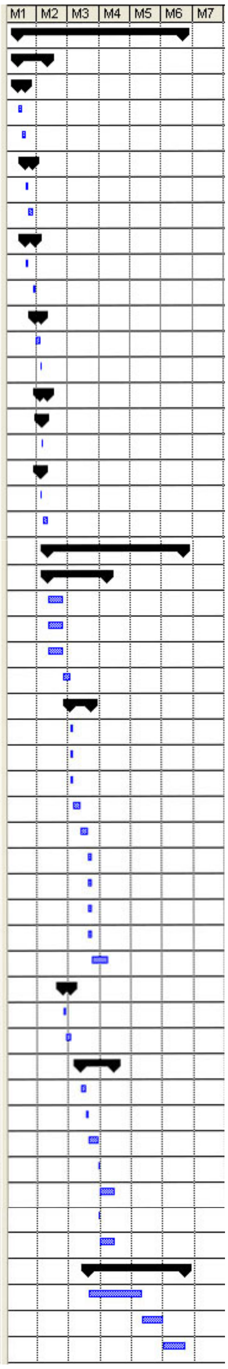

Figure 1: Standard schedule with activities for standard floor

The “contract management” characteristics and those of a large number of revisions are better represented with the use of DSM. The DSM processing (Figure 2), taking into account the interactions among the activities that were not reporesented in the company planning, showed the blocks in which the design delivery and revisions occur, thus making analysis much easier.

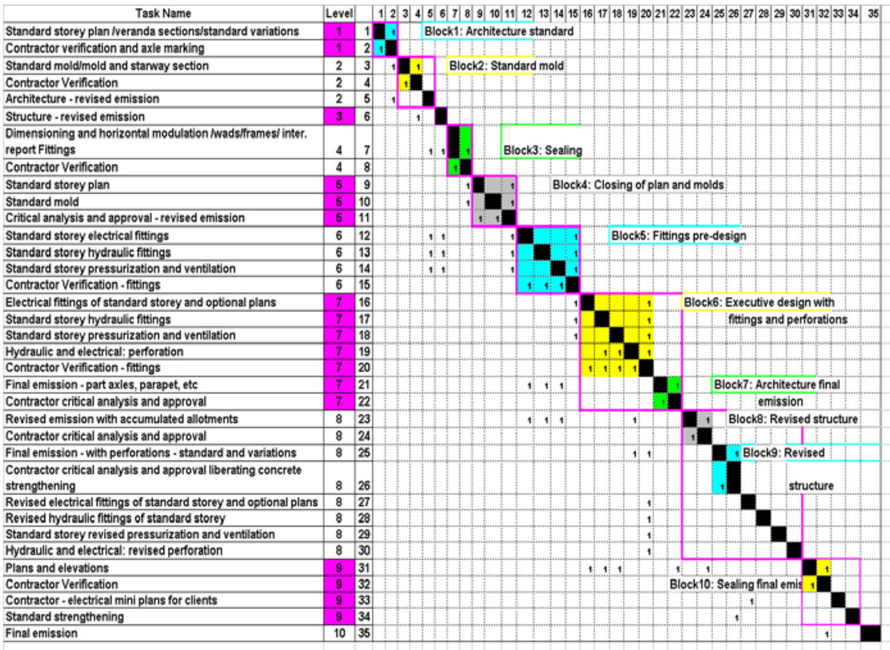

Figure 2: DSM processed with the standard storey activities

The blocks obtained were identified in function of the most important process they represent. Therefore, this new nomenclature revealed the following logical structure:

Block 1 (blue): Architecture standard. Preliminary architectural plan of the standard storey: it is the document deriving from the design made for the municipality, and will serve as a base for developing the other designs.

Block 2 (yellow): Standard mold. Standard mold design developed as from the preliminary version of the architecture developed in block 1.

Block 3 (green): Sealing. Sealing design developed as from the molds and from the architecture, this design usually generates cycles for the former activities, once it works with vertical and horizontal modulation parameters.

Block 4 (grey): Closing of plan and molds. After the revisions of the former designs and of the modulation development, it is possible to close an architecture plan compatible with the structure and sealing plans.

Block 5 (blue): Fittings pre-design. This design is basic and is being started after the plan and standard mold closing. An alternative option to be considered is starting it parallelly with the architecture.

Block 6 (yellow): Executive design with fittings and their perforations. After the revisions cycle, the executive project provides the perforations of the tubulation for the structural design.

Block 7 (green): Architecture final Emission. After the conclusion of the fittings executive project.

Block 8 (grey) and Block 9 (blue): Revised structure and final emission. Two sequential blocks in which the structure receives the perforations, and an emission, verification and final emission cycle is made, liberating the design for strengthening.

Block 10 (yellow): Sealing final emission. After the total conclusion of the architecture, structure and fittings designs, a sealing design is made; for being a production design, it has to wait for the conclusion of the others. The final revision and emissions are placed in a sequence. An alternative option would be to create some parallelism between these activities to make the design final deadline shorter.

There are also the activities that were not grouped into blocks, but are within level 8, such as the final emission of the fittings design.

The model adopted presents a large number of repetitive activities called “revised revision and emission”, a consequence of the company management system, which foresees a very centralized control, where practicaly all works undergo coordination verifications before they are continued.

The representation of all these revisions generated a complicated model with many repeated activities, giving a false impression of complexity. It is important at this point to seek simplification to improve understanding.

The fittings design activities are repeated in three successive cycles, which may be condensed. One proposition is to eliminate block 6 activities, as they are mere revisions, except for the hydraulic and electric perforation activity, which may be incorporated to the set of fitting activities of block 5. Attention should be given to placing perforations emission as the last activity of the block. Similarly, the activities numbered 36 to 40, also revisions, may be incorporated to block 5.

Block 5 may thus be transformed into a block contemplating the whole extension of the fittings design. Considering the deadlines existing in the activities eliminated, their total deadline, 15 days each, was added to the activities in block 5.

Another strategy adopted was that of starting the fittings designs soon after the preliminary architecture plan, instead of waiting for the conclusion of the standard mold design. This earlier beginning increases the project parallelism and, to prevent compatibilization problems, the end of the fittings design was linked to the end of the architecture and mold designs.

To conclude, the sealing design, the deadline of which is quite long, 35 days, added to 15 days for verifications and 15 more for final emission, had its deadline reduced by 5 days, and the verifications and final emission activities were conducted with a parallelism degree of 5 days each, and not totally sequential, as originally devised.

These modifications allowed reducing the deadline of this stage of the project from 112 to 81 days, besides decreasing the number of activities in the schedule from 51 to 32.

Despite the limitations imposed by the model, mainly the lack of detailing at the lower levels of the hierarchy, it was possible to suggest strategic changes, increasing the parallelism of activities and simplifying the process by eliminating redundant activities.

The schedule of the atypical stroreys design also underwent a similar re-study, reaching a reduction from 150 to 95 days, besides simplifying the model with a reduction in the number of activities to be controlled.

At the end of the process, the two schedules, that of the standard storeys and that of the atypical storeys, were assembled at the same time and two global deadline possibilities for the project were simulated:

The first, in which the development of the design for the standard storey before the atypical storeys was kept as a precedence, resulting in a total deadline of 126 days against the 150 of the initial model.

The second, in which the proposal is that the development of the standard storey occurs totally in parallel with the atypical ones, resulting in a total deadline of 95 days.

There are technical implications to be better studied when working a total parallelism between these stages. It is thus recommended that the 126 days deadline for normal development is adopted as a standard, since it is already shorter than the 150 days proposed. For situations in which a maximum deadline compression is necessary, 95 days can be worked with, as long as the interfaces between the standard and atypical storeys are well characterized and worked on simultaneously.

3.1 Control Analysis

The project ended at the end of January, and the schedule had its final updating in early February. The schedule as a whole suffered an 11-day delay, which, within the initial 150-day deadline, represents less than 10%, which would be quite reasonable. However, the model analysis, showed the possibility for compressing the deadlines between 95 to 126 days limits after rationalization measures.

Although delays in important activities were verified, it was noticed that the contractor is not used to regularly surveying and registering the reasons for delays. The lack of this procedure ends up by not relating the necessary corrective actions so as to prevent similar problems.

The delays observed may be classified into two categories:

<u>Delays due to coordination</u>: the lack of coordination due to a one-week holiday caused delays in the verification services and also in controlling designers.

Designers delays: are delivery delays, detected only after the fact has occurred and without more detailed explanations on the reasons that caused the designer delay.

Concerning the delays, the procedure normally adopted by the contractor is that of reprogramming the schedule, which is done by shortening the duration of the future activities, so as to keep the original delivery deadline. It was noticed that this procedure is possible in function of the schedule being planned with a large margin, and of admitting, in advance, the possibility of similar delays.

It was seen that most of the delays were originated by factors within the activities themselves, and these ended up causing delays in the subsequent activities. Many of the problems observed are due to low productivity and the lack of resource allocation on the part of the designers.

In the interviews, it was observed that none of the designers uses planning techniques for allocating resources; these are allocated according to client’s demand up to the moment when super-allocation occurs and delay is consequently generated.

It was also observed that the standard schedule is conceived with excessive margin and alternatives for changes.

In this condition, and for being a design with very simple characteristics, delays would not be justified. This fact reinforces the idea of looking for the causes for delays in the low efficacy of the planning model adopted, in the project management methods and in the designers’ resource allocations.

In the interviews with the coordination and with the designers that were late, a great lack of objectivity in the adequate assessment of the reasons for the delays can be observed, being the excess of tasks in other designs the greatest reason for justifications.

4. Conclusions

Along the research, the purpose was to check the present situation of the design planning, being that, as from the observation of its practices and from the survey of the problems, the main causes for its inefficacy were identified, organized in Table 1.

Table 1: Main causes for planning inefficacy.

Deficiencies in the Management System	
Primary causes	**Factors causing problems**
Management and Coordination of the Design Process	Not very concerned with Management, acting almost exclusively in Compatibilization
	Promotes low interchange among the project team
	Excessively centralized style, hindering communication and turning into a bottleneck for the process
	Adopts the sequential design model, slow and with great lots of information exchange

Primary causes	Factors causing problems
Management and Design Coordination Process	The professionals hiring modality, at closed price, paid before the sequential delivey of designs, with no concern about the contratual scope, generated a management model focusing only on contracts control and on design delivery
	Design process occurs with excessive informality
	Absence of general and integrated planning of the whole of the company designs
	Process control is reactive, actions only being taken after problems have occurred
	Flaws in short-term control
Design professionals	Low productivity justified by the volume of reworks and by overwork
	Resistance to the adoption of planning methods
	Low design quality control, forcing the Project Coordinator to do all the work of designs compatibilization
Use of Information technology	Slow manual design verification routines, without using information technology resources
	Communication is informal and occurs off the extranet environment, with no control by the company
	Hiring the extranet provider is conducted simply by the lowest price criterion
	The predominant use of design extranets has been that of file repository

PLANNING METHODOLOGY	
Inadequate methods	Use of a deterministic model, borrowed from the site-work planning, and focusing on design delivery
	The detailing of the model is insufficient and sees the development of the specialities design as a “black box”
	Excess of revision activities and revised emission transformed into process “bottlenecks”
	Control is exerted assystematically and with no attempt to analyze the causes for delays
	The models do not consider design nature factors: uncertainty, interactivity and variability
	Flaws in planning and short-term control

The investigation of the main problems that harm the efficacy of the design planning process many times escapes the design professionals and hiring companies, which tend to attribute their lack of success to exogenous factors, many times forgetting that these problems derive from their own way of acting.

The lack of planning or inadequate design planning surely leads to a number of reworks, and it may be concluded that the implementation of design planning adequate techniques, coupled to improvements in the management system, are fundamental factors for reducing time waste and for increasing productivity.

4.1 Recommendations to Design Hiring Parts and Designers

The market adopts the global and closed price regimes for design hiring. Payments due are made after the designs partial conclusion and final stages. The characterization of the conclusion of these stages is conducted with the delivery of the corresponding designs to these stages products, conditioning the design flow to occur this way.

The planning models developed are only concerned with controlling these stages conclusion points, without previously establishing, however, the goals to be attained. The research showed that little importance has been given to a precise definition of the hiring scope. For this reason, doubts are raised on the products to be delivered at each of the stages, causing contactors’ dissatisfaction, as they believe they are paying for incomplete services, whereas designers believe they have delivered what had been agreeed.

To improve the planning efficacy will require improvements in the designers’ hiring system, better defining: the hiring scope, the goals to be attained, the building intended performance, the information flow to be generated and the products to be delivered at each stage of the project.

With the introduction of these improvements, the planning model will receive better data to organize the flow of information in a more precise way and so as to turn it into a more efficaceous tool.

Another problematic and conflicting point to be solved in the relations between contractors and designers is the burden of rework. Rework is one of the main factors for the low productivity observed in the design sector.

Burdensome rework and delay in delivering designs are seen by design professionals and contractors as problems; however, the research showed that they are symptoms deriving mainly from the inefficaceous use of the resources allocated to developing designs.

Unforeseen interactions are caused, on the part of hirings, by flaws in product specification originated by ignorance of the clients' needs, by postponing hiring complementary designs which delays the input of important information to the design, causing information gaps which, when fulfilled at later stages, will lead to interactions cycles, and also by the superficial study of the constructive methods to be employed.

The recommendations to contractors is for them to better develop the initial product specifications stage, to organize the team of designers earlier and to include the contributions to designs in the production and in the experience of constructors.

On the part of designers, several causes for unforseen interactions may be listed, such as: design errors, insufficient compatibilization, inadequate use of IT tools, lack of necessary information for developing the work and disorganization caused by lack of planning.

Within the study range of this research, the recommendations to designers aim to promote the use of planning as a project management tool, as it was observed that the design offices ignore the simplest practices. Also suggested is an improvement in the quality control of the product delivered, thus aiming at a decrease in flaws caused by lack of compatibilization, and the the full use of designs extranets is recommended.

A decrease in burdensome rework will only minimize everybody's change in behavior. It is also recommended that, besides the suggestions presented, aiming to improve processes, the contract foresees a financial compensation by the part held responsible, either hiring or hired part, for the cost of rework.

4.2 Recommendations to Project Coordinators

It was observed in the case study that the Coordinator's time is practically taken as design compatibilizer. Acting this way, the Coordinator turns into one more member of the design team, incorporating quality control functions that end up being passed from designers onto him/her.

This is understood to be one of the nuclear problems originating the others, as this deviation in the Coordinator's original functions ends up by relegating process Design Management to a secondary level and perpetualizing obsolete practices. The most important and initial recommendation is for the Coordinator to start acting as Manager, so as to allow the implementation of the other recommendations made next.

It is recommended that Planning starts to be considered by Coordinators as strategic in the design process conduction, and to improve its efficacy, the following is recommended:

- reformulating the process models adopted, abandoning the deterministic models and transforming them into information flow models;
- construction of models that allow a parallel development of the design, which is attained by modeling it into smaller parts which will facilitate a more frequent information exchange;
- using adequate techniques for manipulating these models, such as DSM;
- integrated planning of all the company's designs;
- formalizing the design process;
- project management within the extranets environment, allowing them to manage not only documents, which is the present situation, but also communications and workflow;
- incorporating systematic deadlines control routines with analyses of the causes of deviations, which will allow planning feedback.

4.3 Recommendations to researchers

The methodology studied showed to be powerful and adequate as it allows structuring the design process in function of its information precedences, and not by design delivery sequences.

It is understood that the present methodological content is necessary and enough for effective implementation in the design market; however, recommendations are made for the present limitations of this methodology to be foreseen so as to avoid future bottlenecks.

The key point of this methodology is undoubtedly the construction of an information flow model. The model construction stage is decisive to the process, as from this all the structuring of the data necessary for developing the design will be studied. The DSM technique is an important stage of this methodology, since it allows organizing the information flow, identifying the cycles in which there are interactions between the activities.

DSM allows identifying the rework generated by expected interactions, motivated by revisions and by information exchanges between specialities.

The technique is important, as it allows organizing activities so as to minimize these retrofeeding cycles; however, no technique allows to foresee unexpected interactions, motivated mainly by changes in scope made by clients at advanced desing stages.

DSM showed to be an adequate technique for design planning, as it allows representing the interactivity, reorganizing activities so as to reduce rework cycles, and also a global view of all the process, besides being easy to understand.

Nevertheless, the complexity required for making the DSM, represented by the need for a deep knowledge of the design process at the more elementary level of activities, constitutes a factor that may make the intense use of this technique unfeasible. Another obstacle is the absence of specific softwares in the market.

Another gap acknowledged by the research was the absence of a specific planning technique for the project first stages. DSM is a highly structured technique, not being, therefore, recommended for this stage of the process. Thus, the study of techniques is recommended or the adaptation of the existing one for the project initial stages.

Concerning the development of the methodology, the main recommendations to researchers are summarized as follows:

Aiming at ample dissemination of the technique, the development of design models that may be adequate to the ordinary cases of residential buildings is suggested.

The models should take into consideration the needs for information foreseen in the scope of each speciality; study of techniques for planning the initial stages of the design and development of design process control methods that might automatically be incorporated to the extranets.

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