Tendering Documents versus the Construction Process

A balance to achieve

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Summary

Almost any construction process encounters unforeseen events during its development. Issues, such as insufficient information in the tendering documents, the continuity of the detailed design during the construction process or inexperience of the people involved in the development of the project conduct to time delays and extra costs on the estimated planning.

The main objective of this paper is to present solutions that will contribute to the development of the construction process, thus including the different contingencies that are likely to appear.

To achieve the former goal, a case study will be used. The project that will be analysed is the control building for the Hydroelectric Dam Multipurpose Urra I in Colombia, South America. This building encountered many contingencies in each of the stages of its development. Therefore, by using it as an example recommendations such as the following were concluded.

During the stages of design and production of the tendering documents, an adequate production planning should be settled in order to accomplish the information required for the construction of a building. Clear design objectives, scope of work and the time in which it should be achieved must be one of the main issues to consider when initiating a project.

Regular co-ordination and feedback between the client, the designers and the contractor must be established throughout the different stages in the development of the project. The outcome of this interaction will contribute to achieve the goals pursued by the project.

Technical activities and special installations (HVAC) are an important issue within the construction's planning and cost estimation. The information and co-ordination required by these activities should be completed on the first stages of the project. Its precision will provide defined cost estimates as well as accurate production planning within the construction schedule.

During the construction process realistic planning should be settled. This planning among other issues may be achieved by thorough understanding of the documentation regarding the project, the involvement of adequate professional skill on site as well as the construction activity control.

Finally, it is also concluded that if fundamental issues concerning design, tendering and construction are previously known they should be settled in the project. Occasionally, these determinants are not considered and unnecessary time and cost are wasted on their discussion.

Introduction

During the construction process, the designers of a building usually continue with the development of the detailed design thus variating the information settled in the tendering and construction documents. This often affects the proper development of the construction, as many contingencies will probably appear. Inconveniences will be occasioned to the contractor's planning schedule, as well as variations on the estimated cost for the project.

The aim of this paper is to analyse a process by which the tendering documents of a project should involve the unforeseen aspects of design that may develop during the construction while the architects and designers continue with the process of detailing design.

To illustrate the former purpose, the project that will be described and analysed in this paper is the Control Building for the Hydroelectric Dam Multipurpose Urra I on the Sinú River in the northwestern part of Colombia. Among the different constructions of the dam, this was almost the only building that comprised architectural and architectural detailed design. This circumstance generated many unforeseen events during the construction, due to two major points. On the one hand, the designers continued with the detailed design during the construction process, and on the other hand, the contractor 's experience was on the construction of major engineering structures and not detailed building construction.

In order to illustrate and support the aim pursued, this paper is structured as follows:

The Project: Multipurpose Project Urra I: This section gives the reader an overview of the development of the project of the dam. A brief outline of the historical background, the general characteristics, the actors involved and a description of the specific case study will be provided.

The Control Building Project: This section will describe and analyse the different stages that the control building encountered to its achievement. A description of the process developed, the actors involved and the contingencies confronted will be given for each of the stages of the project.

Conclusions and recommendations: Based on the experience of the case study, and considering the goals pursued by the paper, this section of the paper will present recommendations and conclusions which will hopefully contribute towards a fluent construction process.

The Project: Multipurpose Project Urra I

Historical Background

The first formal studies executed in Colombia on the hydraulic resources of the Sinú river were carried out during the 1950's, when the need to control the river flow by means of the construction of a dam at the high part of its basin was identified.

Later on, the Colombian government authorised the electric sector to begin studies on the hydroelectric development of the basin, which were also complemented with basic studies of the Sinú river eco-systems.

The hydroelectric development of the high Sinú was initially designed with two electricity generating dams, Urra I and Urra II, and as such, the project was included in the Electric Expansion Plan for the 1984-1988 period. This plan was modified when the Urra II construction was indefinitely postponed due to economic and environmental reasons. Then the construction of Urra I was temporarily postponed due to Colombia's estimated electric surplus for the 1986-1990 period.

In 1992, the country went through a long electric shortage, which encouraged the study and approval of the new electricity expansion plan. This study enclosed the Multipurpose Urra I Project as a project already under construction due to the advanced stages of the preliminary civil works. In October 1992 the company "Empresa Urra S.A." was founded as a State's joint company of commercial and industrial character. It's objective was to continue and complete the construction and later on be in charge of the administration and operation of the project.

The project's construction will be financed 40% by investments from national capital and capital of the members of the company (Empresa Urra S.A.ESP), and 60% by national and international commercial bank loans and the capital of some of the suppliers.

The former financing plan was created to support the project's financing framework. Multilateral banks were not called at that time to cooperate for the financing of the project, due to the fact that the processing of the loan with these type of institutions could not be accomplished on time with the construction schedules foreseen by the government.

General Characteristics

The Multipurpose Project Urra I is located on the Sinú River 30 km south of the Tierralta Municipality in the Department of Córdova.

The dam will cover 7400 hectares. Its useful volume will vary between 1200 million cubic meters at the minimum level to 1740 million cubic meters at the maximum flood level. The installed capacity will be 340 MW with four 85 MW units, and with an average electricity output of 1421 GWH/year. The electricity generated will be transmitted through two 230kV lines to the Cerromatoso substation, where it will be interconnected with the national network.

The site for the construction of the dam is at the mouth of the Mano Vieja creek, at the lower extreme of the Urra river narrowing, a gorge of approximately 8 km long, defining the boundary between the High Sinú and the Sinú valley.

The tributary basin of the project is a 4600km² and the average flow is 349m³/s.

The project consists of a 73m high dam wall and a 51m high auxiliary dike wall, with a probable maximum flood level at elevation 132. The maximum and minimum operation levels are designed at elevations 128.5 and 107 respectively. Net hydraulic fall varies according to the level of the dam between 33.6m and 55.9m. Urra I is a medium fall generating central.

The catchment structure is located on the right bank of the Sinú River. Its design consists of an approaching channel and four-screened water intakes, each one with one gate. Its capacity is for 700m³/s.

The powerhouse is located on the surface, on the right bank of the river. It will comprise four Francis vertical axis turbines, with a design flow of 175m³/s each, directly connected to four generator units, with an installed capacity of 85 MW each.

Within the whole complex, minor buildings are required to support the operation and functioning of the major structures of the project. The buildings classified as minor buildings are the following: the control building, the booths for the equipment required for the catchment structure and the dam, and the entrance building to the dam's complex.

The period required for the construction of the project is seven years. The initiation of the project was in July 1993. The finalisation of the civil construction and the installation of equipment are scheduled for April 2000. By September 2000, the four units in the powerhouse will be generating electricity.

The Actors and their Responsibilities within the Main Contract

The Client: Urra S.A. ESP
Urra, Sociedad Anónima. Empresa de Servicios Públicos, is the owner of the project. Urra S.A.ESP is a State's joint company of commercial and industrial character that was created to construct, administer and operate the hydroelectric dam of Urra I. Its members are both of the public and private sector. The main responsibility of the client is to find the financing for the projects construction, to hire the consultants, the different contractors, and the supervision on site as well as to administer the whole mechanism for the accomplishment of the project. Other responsibilities are related with the definition of the future requirements for the adequate operation and functioning of the organisation.

The Consultant: Gomez, Cajiao y Asociados S.A.
Gomez, Cajiao y Asociados, Sociedad Anónima is the engineering consulting firm in charge of the engineering and the architectural design of the project, as well as of the assessment of the design on site. It is important to highlight that the client transferred all the responsibility to the consultant, where the development for the completion of the project is concerned.

Therefore, the consultant's responsibilities are to execute the necessary design, to co-ordinate the technical issues, to prepare the complete sets of tendering documents for the bidders in each of the different projects required by the dam and to co-ordinate the inquires of the different contractors on site (assessment on site).

The assessment on site is a role where the consultant is not responsible for the construction's supervision, yet, there is a team of the consultant on site, which is evaluating and solving the problems that appear during the construction. This activity is carried out through the intermediation of the site supervision.

Site Supervision: Consorcio CEC
A joint consortium integrated by the following Colombian firms: Consultoría Colombiana, Estudios Técnicos and Consultores del Desarrollo. Their responsibilities are the construction supervision on site and the budget control of the construction. They also act as intermediaries between the different contractors, the consultant and the client.

The Civil Contractor: Skanska -Conciviles
A Swedish and Colombian consortium which is in charge of the construction of all the civil works of the dam. Its principal responsibility is the adequate completion of the major civil structures of the dam.

The Mechanical Contractor: Energomachexport - EME
Energomachexport- EME: A Russian contractor in charge of the manufacturing, supplying and installation of the electromechanical equipment.

Organisation Plan within the Main Project

The following organisation chart illustrates the interrelation between the actors previously described:

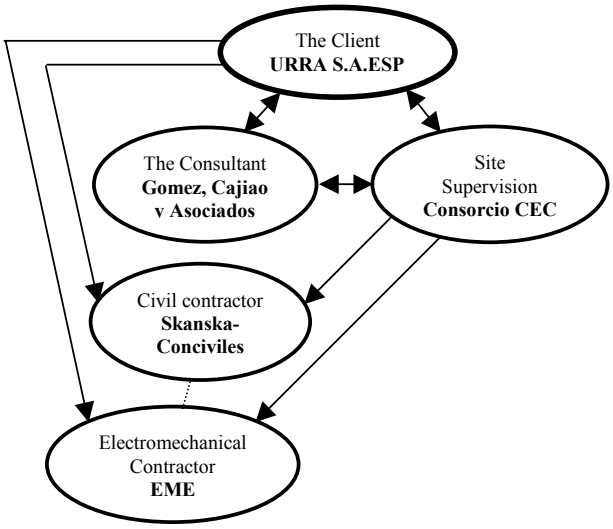

Figure 1- Organisation plan within the main project

The Control Building Project

The building, is a minor construction among the whole complex. The technical activities that will take place within its core are important for the electricity's generation and transmission process. These activities refer to the supervision, monitoring and control of the process mentioned above. The equipment contained in the building will be interconnected to the equipment in the powerhouse (energy generated) as well as to the equipment in the substation (energy to be transmitted). The building is also meant to contain the headquarters of Urra S.A. ESP (the Client) on site.

In order to comprehend the evolution of the project, it is necessary to outline briefly the stages and the actors involved in the process of its development.

Initially, among the minor constructions of the dam the requirement for a control building was settled. It's design and construction development was embodied within the general construction schedule for the dam. Both the times span for the design and the construction were linked to the technical and civil works required within the complex. When the demand for the building became significant among the planning schedule of the complex; the consultant set with the client, the resources, the organisation and the time planning required both for the development of the design and the production of the tendering documents.

Once the stages of design and production of the tendering documents were concluded, the consultant delivered the documents to the client. Thereon, the site

supervision (CEC) with the client would develop the bidding process to select the civil contractor.

The analysis of the bidding and the preliminary selection of the contractor, were accomplished by the site supervision, which subsequently handed them to the client. The client made the final decision on the contractor selected.

With the civil contractor selected, the final phase in the process was the construction and completion of the building. In this stage the client, the consultant, the site supervision, the civil contractor and the electro-mechanical contractor were involved in order to adjust the timing and finalisation of the building according to the general requirements of the dam.

Organisation Plan for the Development and Construction of the Control Building

The organisation plan for the design and construction of the Control Building was settled as follows:

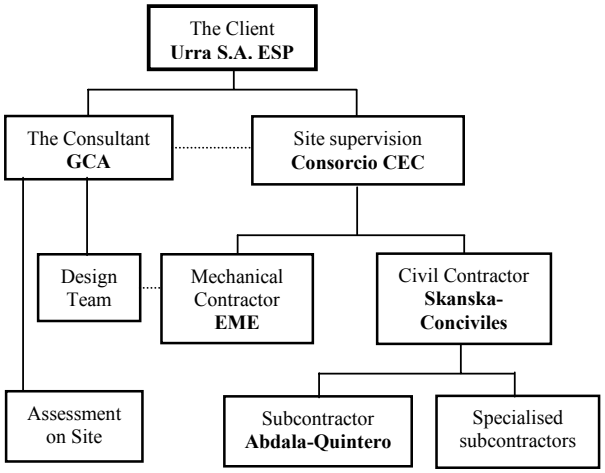

Figure 2-Organisation plan for the development of the control Building.

Design Stage

1. Project Planning

The cronogram for the design and construction of the project was scheduled within the construction requirements of the dam, the budget allocations and the arrival of the electronical equipment for the building.

The programming for the complete design of the building (architecture and other disciplines) was scheduled for a period of eight months and the programming for its construction and completion considered a nine-month period.

2. Project Organisation

During the design stage, the actors and their responsibilities were arranged as follows:
The Client (Urra S.A.ESP): At this stage the client's responsibility is the budget allocation for the financing of the building and the definition to the consultant of the parameters and needs that it will require in the headquarters of the building.

Electro-mechanical equipment fabricator and supplier (EME): In charge of defining to the consultant the technical specifications and requirements of the equipment for the building.

The Consultant (GCA): In charge of the architectural and engineering design. The consultant's responsibility was to co-ordinate within the design of the building both the technical requirements and the headquarters program. During this stage the consultant's responsibility was the production and submission of the complete construction drawings and tendering documents in the disciplines required.

Construction material manufacturers: Second role actors involved in the project by the consultant. Their function was to provide all the necessary information on the construction materials, their application and their specifications and requirements. Eventually these manufacturers also provided the cost of the materials, which were later included in the project's estimated cost.

3. Design Process

The development of the design for this project started with the definition of the architectural area and space program, where two aspects were taken into account: the technical and space requirements for the electro-mechanical equipment and the space demands for the headquarters of the client on site.

The electro-mechanical equipment suppliers adequately provided technical issues of the equipment as well as its area necessities. Technical drawings and general characteristics of the requirements where received in time and developed fluently within the design of the building. Yet, the first problem encountered during the design process appeared at this early stage and is related where the headquarters for the client are concerned. The client, never defined its space necessities to the designers in the consulting firm thus obliging the design team to define the program for the offices required.

The design process also required an investigation of the available construction materials in the area. The architect in charge of the design in the consulting firm travelled to the area and completed the field investigation.

Having thus completed the steps mentioned above, the design of the building began to take place pursuing the following procedure:

- Development of architectural design (general and details).
- Development of specific design: structural, electrical, hydraulic and sanitary, fire protection and mechanical (air conditioning and ventilation).
- Design co-ordination within the different disciplines.
- Completion of the design stage with complete working drawings for all the disciplines required.

As the aim for this project was to produce an integrated design which subsequently would not cause contingencies during construction; the design procedure considered a constant interaction between the different specialities of design as well as communication and consults with the suppliers of the technical equipment and the materials specified.

4. TheTendering Documents

In relationship to the production of the tendering documents, it is important to point out that this building, considered as a minor construction, was not agreed among the structures to be developed within the main contract of the dam. Therefore, the development for its construction offered two alternatives. On the one hand, it could be included as an "extra work" within the main contract and on the other hand, it could be adjudicated to a different contractor than the civil contractor of the major structures of the dam (Skanska–Conciviles). Within those parameters, the tendering documents produced required thorough information for construction in order for the bidders to submit accurate proposals and for the client to elaborate the budget appropriation for the building within the general financing of the project.

The consultant was responsible for the production of these documents, which consisted of the following:

- Design: general and detailed drawings for construction in all disciplines.
- Building specifications
- Bill of quantities
- Cost estimation (official budget for the client). This budget was to be used as a reference with the offers presented by the bidders.

The tendering documents delivered to the bidders, consisted of the above mentioned, excluding the official budget. The bidders, handed in their proposals based on the design and construction drawings, the estimated bill of quantities and the building specifications. It is important to mention that the client was looking for a sole contractor. A contractor that could handle the whole construction of the building (all disciplines included).

During the design process and the production of the tendering documents, the second problem encountered, consisted in an internal issue within the consultant's firm. The problem is related to the lack of communication between the director of the project and the team involved in it. The team was not informed of the date for the final submission of the project. Therefore, the team worked at its own pace. When the submit was due, many designs, quantities and building specifications were not properly finished, hence concluded rapidly. Some of the contingencies encountered during the construction stage may be connected to that account.

5. Tendering and Contracting

Although, the selection of the contractor and the type of contract to be used were determined by the client (Urra S.A. ESP), within this process, two other actors were involved:

- *The Consultant (GCA):* It played a minor but important role within this activity. It prepared the estimated construction cost for the project (official budget). This budget, was the basis and the reference point for the final negotiation and the adjudication of the contract.
- *The site supervision (Consorcio CEC):* Its responsibility within this activity was the analysis of the proposals delivered by the bidders and the comparison with the official budget. Their conclusions were handed to the client for the final decision.

As for the type of contract for the construction of the building that could be agreed upon, two type of contracts were considered by the client as alternatives for the final agreement:

- *Unit price contract:* The base for this type of agreement is established on a fixed unitary price for each item of the contract (material and labour), and the contractor is paid for the quantities he bills. This type of contract demands a precise bill of quantities when the estimated budget is produced so that the client may have a correct idea of the cost of the project.

- *A Lump-sum contract:* The base for this type of agreement is a fixed price for the contractor's work. In this type of contract, the client will pay one sum for the whole construction shown in the tendering documents. For this project, the lump sum for the agreement was based on the bill of quantities elaborated by the consultant.

Several construction companies, within the region, were invited to tender. However, a major reason obliged the client to decide on the contractor it selected, thus not being the tenderer who submitted the best economic offer. The determinant was the financing of the building and the budget allocation. By selecting the same civil contractor of the main contract of the dam (Skanska–Conciviles) the finance for the building could be allocated as an "extra work" to the main contract of the dam's construction. This facilitated the project's finance, as its cost was appropriated within the main contract's budget. Otherwise, the financing of the project would have encountered new economic procedures for the loans it required. An issue which would have delayed the initiation of its construction

Therefore, the contract for the construction of the Control building was adjudicated to the same civil contractor of the dam (Skanska-Conciviles), and its construction was included as an "extra work" in the main civil contract.

Within the main contract, the specific arrangement for the construction of this building was determined on a lump-sum contract. The final lump sum settled for its construction was based on the total cost of the official budget, prepared by the consultant and the cost offered by the contractor.

After analysing the budget presented by the contractor, and comparing it to the official budget, the parties agreed on an intermediate lump sum between both budgets. It is important to mention that the parties also agreed on a variation to the lump-sum contract. The agreement was the following: that if after concluding the construction, the total cost would exceed 3% of the original sum settled, the client would recognise the contractor, the extracosts in which it incurred. Whereas, if the total cost of the construction did not reach 97% of the sum, the client would reduce proportionally the amount to be paid.

In order, to achieve the former arrangement and to pursue the economic control of the building, two issues were settled. First, unitary prices for materials were fixed. These were settled according to an equivalent unitary price based on the bill of quantities and the total lump sum of the contract. Second, the contractor would be paid a monthly percentage according to the completed and executed construction. With the previous mechanism, at the end of the construction, the real quantities executed could be easily calculated and the total cost of the project would be settled.

As of today, neither the site supervision nor the civil contractor have delivered the evaluation on the final cost of the building.

Project Planning

As was mentioned before, the time schedule for the design and construction of the building were planned within the construction requirements of the dam, the financing allocations, and the arrival of the electronical equipment that would be located in the building.

The construction of the building was scheduled within a nine month period to its completion and was settled as follows:

- June 22, 1997 Initiation of construction
- February 28, 1998 Deadline of construction.

The schedule was planned on a Gantt bar method, and it contained, all the activities specified in the contract, starting from mobilisation, and concluding with the architectural finishings and detailing.

By February 28,1998, the civil contractor would have to deliver a complete and finished building to the site supervision therefore, to the client. Once the building was received, the electronical and mechanical contractor and supplier would come in to install the technical equipment required in the building. The former planning was settled in order to separate completely the civil works from the installation of delicate technical equipment (separation of the main contractors involved).

Construction Stage

As the tendering documents were produced as complete construction documents, it was possible to initiate the construction of the building immediately after the civil contract was settled.

1. Construction Stage Organisation:

During the construction process, new actors are involved whereas other change their role or the responsibility to be performed.

The Client (Urra S.A.ESP): The client's responsibility was the financing of the building, the budget allocations and the cash flow that would cover the payment agreements settled with the contractor. Where redesign or construction decisions were concerned, the client transferred all the responsibility to the consultant. Where economic issues were concerned, the client was informed by the site supervision. If additional costs would be necessary, the client would authorise or reject the incursion on them.

The Consultant (GCA): The main responsibility during this period is the assessment on site. The consultant is also responsible for the clarification of inquires that may appear on the documents delivered, as well as on solving the contingencies that the construction will probably confront. The team involved at this stage is the following:

- Project Site Director (civil engineer): Permanently based on site. He is responsible of solving the inquires that appear on site by acting as an intermediator between the site supervision and the consultant's design team.
- Civil, electrical, hydraulic and mechanical engineers: Responsible for their design. They must solve the problems and contingencies that may appear during construction. The communication is accomplished through the intermediator (project site director) or when necessary by visits to the construction, where problems are resolved on site.
- Architect: Its responsibilities are the same as the former described. For this project, the architect travelled twice a month to the construction site in order to solve many of the interrogations, which developed during the construction process.

Site Supervision (CEC): For this building, this actor has the same responsibilities as the one he holds for the main contract. It is responsible for the construction's surveillance on site and the supervision and control of the budget. It also acts as an intermediary between the civil contractor, the specialised contractors, the electronical equipment contractor and supplier, the assessment on site and the client. The direct team involved in the construction of the Control building was the following:

- Civil engineer: Responsible for the supervision of the project and of the production of the minutes of construction.
- Site and construction inspectors: Their task was to supervise and inspect the civil construction and the equipment's installation.
- Cost supervisors: In charge of the follow up of the connection between the construction executed and the monthly bills delivered by the contractor. He also approves or rejects the previous payments.

The Civil Contractor: (Skanska- Conciviles). The responsibility of the contractor was to develop the construction of the building as was specified in the contract and in the construction documents (time, quality, cost, etc). In order to achieve the construction of the building, the contractor subcontracted a local civil construction company to whom it transferred all the construction's responsibility. During the first stage of construction, the contractor had no involvement whatsoever with the construction of the building. Subsequently, on that account, many contingencies were generated as the inexperience of the subcontractor brought unfavourable results to the construction process. Consequently, the contractor was obliged to include the following personnel within the construction of the building's organisation:

- Head Civil engineer: Its responsibility was to assist and supervise the subcontractor's work.
- Foremen and construction workers on site: Their responsibility was to work directly in the construction. They collaborated with the subcontractor's workers in order to achieve the targets settled for the building.

The Subcontractor (Abdala –Quintero): A local civil construction company responsible for developing the construction of the building. The basic team for this actor was constituted as follows:

- Head engineer on site: responsible for the development and supervision of the construction. This actor had to study and understand the construction documents in order to direct and follow the construction.
- Foreman
- Construction workers

Specialised Subcontractors: Subcontractors specialised in different areas (air conditioning, ventilation, fire protection and electrical installations). They were engaged by the contractor in order to fulfil the technical specifications required by the building. Their responsibility was the suppliance and installation of the technical equipment concerned. The development of these activities would be jointly co-ordinated between each of the subcontractors, through the intermediation of the site supervision when necessary.

Electronical Equipment Contractor and Supplier (EME): Its responsibility was the suppliance and installation of the specialised electrical equipment required for the building. Their role would take place, once the civil construction of the building was completed. At this point, the installation of delicate equipment would begin and this actor entered the stage.

2. Construction Process:

The construction organisation developed in two stages.

Initially the organisation for the construction process was settled as follows: the civil subcontractor was responsible for the civil works, while the site supervision as well as the assessment on site (consultant) carried out the responsibilities previously described. It is important to point out that in this first stage, there was no presence or construction co-ordination by the civil contractor.

Organisation plan for the construction process

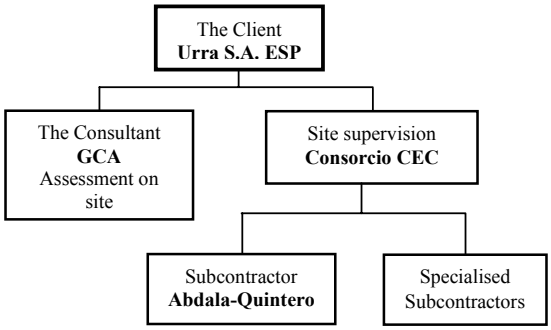

Figure 3- Initial organisation chart

However, two major unforeseen events developed during the first months of construction. These events are mentioned as they induced changes in the construction's organisation. The first one is related to the bill of quantities delivered by the consultant, where a miscalculation on the amount of steel and prefigured steel lead to claims by the contractor. The second one, was a misunderstanding of the architectural drawings by the subcontractor, where the details for the facade walls were not constructed as specified.

These two errors, one for each party, caused a significant delay, as the construction was stopped for a considerable period of time while the parties negotiated on their mutual claims. The contractor reclaimed for the extracosts of the steel, while the client (represented by the site supervision and the consultant), argued that the walls already constructed would have to be rebuilt.

On the former issue, the final agreement was the following: the subcontractor, would not get paid for the extra amount of steel it incurred, while the client, would accept the way in which the walls had been constructed.

However, the error on the subcontractors account, lead to two major changes: on the one hand, the designers were obliged to redesign the wall details for the facades, and on the other hand, as was previously mentioned, the contractor adapted a new construction organisation plan. The civil contractor decided to involve itself directly in the construction of the building by supervising and supporting the work of the subcontractor. Therefore, on the contractor's account, a civil engineer, foreman and construction workers were involved in the process.

Thereon, the construction organisation developed as follows: the subcontractor (supervised and supported by the contractor) was responsible for the civil construction. The site supervision verified the completed construction, elaborated the budget control and the minutes of construction, and the assessment on site provided the

necessary additional information in order to complete the project.

Organisation plan for the construction process

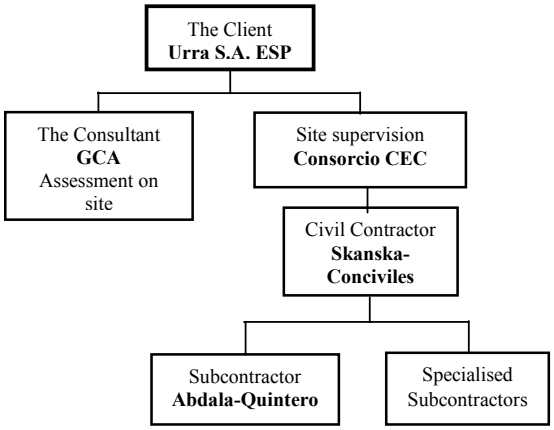

Figure 4- Contingency organisation chart

Although the former procedure seemed to be carefully planned, at this stage, an additional problem encountered should be mentioned. The problem is related to the professional resources involved in the process. The lack of an architect both within the civil contractor and the site supervision teams'. The construction confronted many difficulties as engineers, who lacked experience in this field supervised the architectural details.

This lead to a closer surveillance of the construction by the consultant. The architect on the consultant's team was obliged to travel twice per month to the site in order to solve the inquiries encountered and to supervise the detailing of the architectural finishes. After every visit, the architect wrote a report, where the issues discussed on his visit were cleared. Often, these reports included clarification drawings or new details to complete the construction. The reports were sent to the site supervision and thereon, to the contractor.

If problems that appeared could be solved on site, three actors were involved: the consultant (the architect or other specialists), the site supervision (the head engineer) and the contractor (the contractor's engineer as well as the subcontractor's representant). But, by no means, the consultant could solve the problems directly to the contractor or subcontractor. It is important to understand that the presence of the site supervision (the intermediator) was always required.

This scheme lead to constant delays in the development of the construction as minor problems that could have been easily solved on site always required the visit of the consultant's architect.

Furthermore, during the construction, the consultant's design team delivered additional details and drawings in order to complement or clarify the information settled in the tendering documents. This information originated further delays thus causing claims by the contractor.

Although the contingencies described were significant issues to the construction process, additional and constant eventualities appeared, which continued to delay the time schedule foreseen and obliged the parties involved to reprogram the construction of the building.

Favourably, to the construction process, the arrival of the electronical equipment was delayed. Therefore, the new time schedule, was co-ordinated with the electronical and mechanical contractor, in order to fulfil the requirements for the arrival of the electronical equipment. The final submission for the project was deferred for an additional period of two months with respect to the date initially settled. At this point, no major consequences influenced the construction or the planning within the dam's projects. Both parties mutually accepted the additional term and no penalties were charged to the contractor, as the delays were considered on the account of the main groups involved.

However, the civil contractor was not able to meet the settled date. Once more, an additional time planning was required, as the building could not be completed for the arrival of the electronical equipment. A contingency plan was settled, in order to achieve the requirements of the electrical and mechanical contractor.

The arrangement was the following: on a first instance, the civil contractor would finish completely the spaces where the electronical equipment would be installed. The completion of the rooms included all civil works and the technical specifications required by the equipment: electricity, air conditioning, and ventilation, fire protection, etc. This way, the electrical and mechanical contractor, would initiate the installation of the equipment in order to accomplish the technical co-ordination with other projects of the dam. On a second instance, the civil contractor would continue with the completion of the areas of the building i.e. the headquarters for the client.

It is important to point out that the rescheduling of the construction was also possible due to the fact that both the civil contractor and the electric and mechanical contractor remained on site. This permitted rapid construction co-ordination between the parties, as communication was easily available.

In conclusion the experience of the subcontractor was not sufficient for the adequate construction of the building. Therefore, it should be said that where the organisation and development plans are concerned, the construction of the building was principally attended by the engineers and architects both on the contractor's and the client's account (assessment on site and site supervision). These teams worked together in order to accomplish the completion of the building.

Property Management

Considering that the project of the dam is not completed today, the issues in property management that will be discussed are related with the plans that are pursued both for the maintenance and operation of the complex. The estimated life cycle for the project is a fifty-year period.

The structures and buildings are being constructed with first quality materials in order to accomplish long lasting structures, which will require seldom maintenance.

The operation of the dam as well as its property management will be set out to tender. The future operator

and contractor for these activities will be responsible both for the operation and the maintenance of the dam.

Where the buildings and structures are concerned, the contract includes conditions related to the adequate preservation of the major structures, the minor buildings and the sustenance systems. Repainting, roof and urban exteriors maintenance, permanent revision and control of the hydraulic, sanitary, fire protection, HVAC, electricity systems, etc. will be among the issues that the future operator and contractor will be responsible to carry out.

Where the equipment is concerned, the manufacturers will provide the owner of the project (Urra S.A. ESP) with technical operation and maintenance manuals. These technical manuals constitute a part of the operation and maintenance contract and their requirements and specifications should be carried out by the operator and contractor.

Conclusions and Recommendations:

Within the framework of the past case study, the following section of this paper aims to suggest alternatives and solutions that may contribute to the process of an accomplishment of a building. A process that develops from the initiation of the idea of a project (design stage), to the moment in which it is wholly completed (construction process and the building itself).

Issues, such as the relationship between the construction documents (drawings, construction drawings, building specifications, bill of quantities, etc.) and the process of the construction itself will be highlighted. The following analysis will be carried out by describing briefly the problems encountered and mentioned during each stage and subsequently presenting alternative solutions.

Design Stage

The problems that developed at an early stage of the construction process of the control building may be attributed to different causes. The first cause is related with the design process and the production of the tendering documents. As was mentioned, during this stage, the consultant's team was not apprised of two main issues: the client did not define its headquarters' space requirements, and the director of the project in the consultant's firm did not inform the team of the submittal date for the project. Consequently, the team was not clear on the goals, or the time in which the work was meant to be achieved.

During the stages of design and production of the tendering documents, an adequate production planning should be settled in order to accomplish the documents required for the construction of a building. Clear defined objectives should be determined and the teams involved must be informed which is the scope of the work and the time in which it should be achieved. During these stages, the following issues are recommended to be taken into account:

General Design Stage:

- Planning schedules and project organisation should be settled: Which are the goals of this work? What documents will be produced? Which is the time in which it should be accomplished? What are the resources of people, equipment and materials that will be needed? Which is the financing required?
- A clear design program must be settled: the client's functions and necessities determine the definition of the space program for a building. Additionally the design must include the technical issues that the project will demand according to the previous requirements.
- Which are the types of architectural finishes that the client demands? Do they adjust to the client's estimated budget? If not, which are the alternatives?
- Co-ordination and feedback between the client and the consultant: Once the consultant is clear on the client's requirements, the consultant should elaborate an initial design scheme for the client's discussion and approval. The detailing process should begin once all the general design issues have been discussed and approved by the client.
- Technical co-ordination between the different specialities. Interaction between the members of the design team in order to achieve the co-ordination required among the different technical issues required by the project.

Detailed Design Stage*:*

The detailing design stage is a complex process where the construction drawings are produced. This stage requires technical applications and co-ordination as well as materials' investigations and requirements. The drawings that are produced in this stage, are the drawings that will give shape to a building, that is to say, the construction drawings.

In the project analysed, it was briefly mentioned, that the consultant's team, continued delivering detail drawings during the construction process of the building. Therefore, some of the delays encountered by the construction may be appointed on that account.

As the experience in this project as well as in other projects, shows that constantly the designers of a building continue with the detailing design during the period of construction; some recommendations will be given in order to facilitate an issue which is commonly confronted and hardly unavoidable.

- Within the design stage production, the designers of a building are recommended to elaborate a list of the details that are going to be produced. This list should be made according to the general design requirements and in the chronological order in which the construction activities will take place. The details should be produced according to the sequence of activities required by the construction process.
- The list of details should be delivered to the client for verification and approval.
- The list should be included as a section of the tendering documents. Therefore, if all the drawings and details are not covered within the tendering

documents, the contractor will have an idea of the scope of the work he is expected to achieve.

Tendering Documents

The production of the tendering documents should begin once the general design issues have been discussed and approved by the client. These documents must provide the tenders, hence the future contractor, clear and accurate information of what the project will require: general drawings, construction drawings, construction specifications, bill of quantities, contract formats, etc.

In relation to the tendering documents, the issues that developed in the project analysed are concerned with miscalculations in the bill of quantities delivered to the tenders and insufficient construction details within the documents. The experience on that account leads to the following conclusions which may be taken into consideration:

- Bill of quantities: The bill of quantities should be accurate. Therefore, the team responsible for their production should plan the realistic time for the elaboration of the quantities. However, in order to avoid eventualities during the construction, the tendering documents should specify that the tenders must revise the quantities. This recommendation conducts to the fact that when the documents are set for the bid, the tenderer must be allowed a period of time to make its calculations. The purpose of the previous recommendation is to insure a double check in the quantities.
- When the detail information is not complete in the tendering documents, two issues are suggested. On the one hand, the list of details, previously recommended, should be contained within the information delivered. On the other hand, the designers and quantity surveyors should include within the bill of quantities, rough estimates of the materials that they are planning to be use in the details. Thus the previous suggestion will not provide accurate quantities nor accurate cost estimates, it aims to provide both the contractor and the client an approximate idea of what is going to be produced.
- The construction drawings and the building specifications should include a double alternative in the materials to be used (materials that are equivalent in appearance, quality and cost). Therefore, if a specified material is not available during the construction process, the contractor will have at hand another alternative and construction delays may be avoided.
- Technical activities and special installations (HVAC) are an important issue within the construction's planning and cost estimation. Therefore, the tendering documents should aim to provide and complete all the information required by these activities. Its precision, at an early stage of the project will provide defined cost estimates as well as accurate production planning within the construction schedule.

Construction Process Stage

Within the setting of the project analysed, the causes that will be mentioned which influenced the construction process are the following. On the one hand, the construction started immediately after the contract was signed, consequently, the teams involved in the project did not to have the time to study the documents thoroughly before the initiation of the construction. On the other hand, the lack of an architect on site both on the contractor's and site supervision's account. This lead to the fact that architecture construction details were guided and supervised by engineers, thus producing contrary effects on the settled design.

The recommendations suggested on behalf of the former issues as well as on experience in other projects, are the following:

- Before the initiation of the construction, the team that will be involved in its development should have the time to study the documents delivered. By doing so, a clear perception and knowledge of the project is achieved and insufficiencies or lack of necessary information may be detected on time.
- Realistic production planning for the construction stage should be settled. The list of details suggested in the design stage and contained in the tendering documents will support the construction schedule. If details are insufficient in the documentation delivered; with this list, the contractor may co-ordinate within its schedule, the submittal of the missing information required by the consultant.
- When projects involve architectural detailing, the presence of an architect on site is required. Its responsibility is to resolve the problems which develop during construction process but which do not require the attendance of the main designer.
- Regular construction co-ordination meetings must be settled. The contractor, the consultant (designers) and the site supervision (if one has been appointed), should attend these meetings. The aim of these meetings is to state and resolve problems within the different parties involved. Their regularity will be defined according to the construction's requirements.
- Meetings on site with the client should also be settled. This proposal pursues the client's follows up on the construction process and its acknowledgement in the development of the project.
- The designers of the building (architects, engineers and others) should be acquainted with the development of the construction. Regular site supervision is necessary in order to inspect and solve any of the construction issues that constantly appear.
- Construction activities control: The activities completed or in execution should be periodically controlled by comparing them both to the construction's planning schedule as to the estimated budget. If problems, delays or extracosts are detected, the parties involved should develop contingency plans for their solutions.

Furthermore, in any of the stages previously mentioned a general recommendation may be applied: the client, the consultant and the contractor(s) should assure that the period scheduled for a work is in reality the time it will embrace. If the term is extended, the estimated planning production and the costs will be modified.

Other Conclusions

The brief ideas that follow are concentrated on the particular topics that developed within the case study analysed. They are deliberated in this section of the paper, in order to suggest possible solutions to problems which may develop in similar projects.

The first issue to be discussed relates to the tendering documents and the selection of the contractor. As was described, the main reason for the client to decide on the contractor it selected was the fact that the financing for the project could be allocated within the main's contract budget. This paper questions the fact that the client put the building to tender when major financial determinants would finally conduct him to the decision taken.

The production of the tendering documents takes effort, time and cost. Therefore, if the contractor selected, in a way, was previously chosen, unnecessary investments in these activities were achieved.

However, it may be understood that by setting project out to tender, the client pursued comparisons between the different proposals. The following alternatives could have been applied in order to achieve these comparisons: a comparison with the official budget elaborated by the client and a comparison with a budget prepared by the site supervision team. Additionally, references with the projects that were being carried out by the civil contractor within the dam's complex could have given the client a basis for the negotiations.

The second issue to be discussed is the role that was carried by the site supervision. With the presence of the assessment on site (consultant), the site supervision transferred part of its responsibility to the former, thus not carrying out any of the activities concerned with the construction. Hence, it may be concluded that having both an assessment on site as well as site supervision may be redundant thus increasing the construction costs.

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