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*Project management en el
caso de la rehabilitación
de la infraestructura de la
Universidad de Concepción,
Chile, posterremoto m8.8*

Project management applied to the infrastructure rehabilitation at the Universidad de Concepción Chile, following an m8.8 Earthquake



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Abstract

Although the buildings of the Universidad de Concepción (UdeC) stood up well structurally to the effects of the earthquake on 27 February 2010 in Concepción, Chile, diverse damage was generated in their non-structural elements. Due to the large number of university buildings (over 100 on the Concepción Campus alone) and the need to start classes on 5 April, numerous simultaneous repair projects were generated. These were done

within the national post-earthquake context and the specific context of the UdeC.

The objective of the present article is to determine the applicability of Project Management in the particular case of the UdeC infrastructure rehabilitation projects.

Project Management was found to be not only applicable in this case but also absolutely necessary in order to achieve the objectives of the projects.

Key words: Project Management; Earthquake; Massive Repair Projects.

Resumen

Desde el punto de vista estructural, la Universidad de Concepción (UdeC) resistió bien los efectos del terremoto del 27 de Febrero de 2010 en Concepción, Chile. Sin embargo, sí se generaron diversos daños en los elementos no estructurales de los edificios. Debido a la gran cantidad de edificios de la universidad (sobre 100 solo en el Campus Concepción), y a la necesidad de iniciar las clases el 5 de Abril, se generaron numerosos proyectos de reparación si-

multáneos que estuvieron enmarcados en la situación post-terremoto en Chile y las particularidades de la UdeC.

En este contexto el objetivo del presente artículo es determinar la aplicabilidad del Project Management en el caso particular de los proyectos de rehabilitación de la infraestructura de la UdeC.

Se concluyó que el Project Management no solo fue aplicable en este caso, sino absolutamente necesario para el logro de los objetivos de los proyectos.

Palabras clave: Project Management; Terremoto; Proyectos de Reparación Masiva.

1. Introduction

1.1 Background

The APM definition of Project Management states that this is “the process by which projects are defined, planned, supervised, controlled, and delivered such that the agreed benefits are realized” (APM, 2006). This manner of tackling projects can be applicable in different situations.

Project Context refers to the environment in which a project is carried out. An adequate appreciation of the context in which the project will be carried out helps those involved in Project Management (APM, 2006).

In particular, this article considers the applicability of Project Management in the specific case of the Universidad de Concepción (UdeC) infrastructure rehabilitation projects following the earthquake of 27 February 2010.

The UdeC was created in 1919 and at present it has 22,623 undergraduate students and 1581 graduate students who develop their activities on three campuses, one each in the cities of Concepción, Chillán, and Los Ángeles (UdeC, 2010a). The main campus in Concepción alone has more than 100 buildings. Thus, the administration of the massive university rehabilitation projects presented a technical and managerial challenge in which the organizational culture of an institution of higher education and the specific context of the UdeC must be considered.

1.2 Objective

To determine the applicability of Project Management in the particular case of the UdeC infrastructure rehabilitation projects resulting from the earthquake on 27 February 2010 in Chile.

2. Development

2.1 Infrastructure of the Universidad de Concepción

The urban surface of the Universidad de Concepción totals 1,425,900 m², with a total of 243,556 m² in buildings distributed over three campuses: Concepción, Chillán, and Los Ángeles (UdeC, 2010b).

The main campus in Concepción has more than 100 buildings including classrooms, libraries, laboratories, workshops, research centers, offices, gyms, eateries,

clinics, an observatory, art gallery, museum, daycare center, and television station, plus other facilities such as a stadium, courts for multiple sports, tennis courts, containing walls, paved roads and walkways, etc. Moreover, the UdeC has a theater, five university residence halls, an interactive center, and a technological development unit in and around the city of Concepción (UdeC, 2010b).

Finally, there is a Technical Training Center in the city of Lota and a Marine Biology Station in Dichato (UdeC, 2010b).

2.2 Earthquake of 27 February 2010, Concepción, Chile

The 8.8 magnitude earthquake that occurred on 27 February at 03:34 a.m. (local time) in central Chile was caused by the sudden displacement of the Nazca plate under the South American plate in an area that extended from approximately the Arauco Peninsula on the south to Pichilemu on the north, covering about 450 km in length in a practically north-south direction and a width of some 150 km (Barrientos, 2010). The epicenter was located in the Pacific Ocean off Curanipe and Cobquecura, about 150 km northwest of Concepción (USGS, 2010).

The seismic zoning proposed in the standards for Seismic Building Design NCh 433, enacted in 1996 and modified in 2009, locates the city of Concepción in Zone 3 given its proximity to the coast (subduction quakes); this classification corresponds to the area of greatest effective acceleration (INN, 2009). The standard further designates four types of ground for the generation of design spectra. In this sense, the neighborhood of the university is categorized as Type III and some sectors are rated Type IV, that is, soft ground that is constantly saturated and poorly drained. Thus, this area requires design spectra that comply with the most stringent demands set out in the standards and with a high probability for dynamic amplification.

Consequently, the university buildings are designed largely around the concept of rigid structures, based mostly on structural walls and a system of rigid foundations conveniently tied down in the two orthogonal directions of the structuration. In many cases, these buildings have a foundation slab as well as piles.

The very good seismic behavior of the buildings was apparently due to the use of this structuration system in recent years.

2.3 Technical Committee for the Rehabilitation of the UdeC Infrastructure

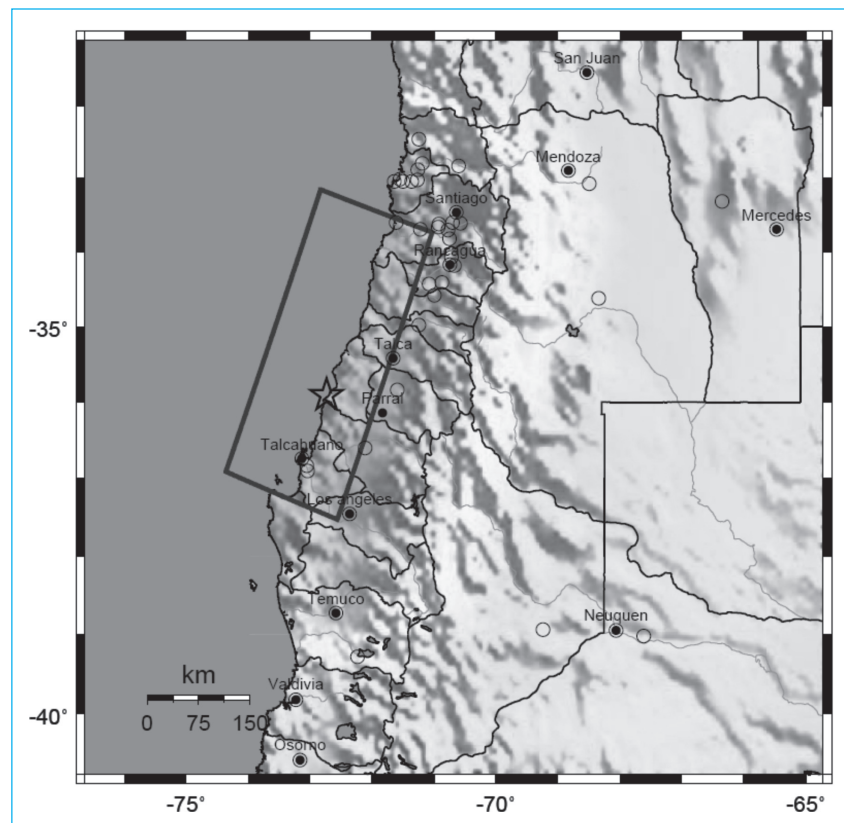
Immediately after the earthquake and due mainly to the abundant damage observed on the campus, the university authority decided to create an organization that would be able to administer both the evaluations and the future repair contracts with all their particularities.

One of the fundamental variables to consider was the urgency of making the university facilities habitable in order to start undergraduate classes on 5 April 2010. Thus, the Technical Committee for the Rehabilitation of the UdeC Infrastructure (TCUDEC) was established. The TCUDEC was made up of professors from the Civil Engineering Department and staff from the UdeC Direction of Services.

The engineer Mario Valenzuela O. was designated Director of this committee or Project Manager; Mr. Valenzuela is a professor in the Department of Civil Engineering. Mauricio Pradena M., also an engineer and a professor of this same department, was chosen to provide direct consulting in Project Management.

The Direction of Services is the unit responsible for the projects, construction, and maintenance of the university infrastructure. Staff members, mostly engineers specialized in administration and the technical inspection of works, were chosen from this unit to participate on the committee and they were active in all stages of the repair projects. Their contribution, as opposed to that of others external to UdeC, was rooted in their great knowledge of the UdeC infrastructure and its functioning, as well as their sense of belonging to the university community.

Figure 1. Diagram showing the epicenter of the earthquake on 27 February 2010 (USGS, 2010)



A team of professors from the Civil Engineering Department, all important consultants for private engineering activities, advised the TCUDEC. These consultants are outstanding professionals with vast experience.

According to APM (2006), a Project Office “serves the organization’s project management needs”, whether offering basic support for the Project Manager or linking the corporate strategy with the execution of the project. Considering this definition, the Technical Committee for the Rehabilitation of the UdeC Infrastructure complied with the functions of Project Office for the case presented in this article.

2.4 Beginning of the committee work

2.4.1 Structural evaluation of buildings

The first activity, practically spontaneous, was the structural evaluation of the UdeC buildings. This was done mainly by professors of the Civil Engineering Department.

According to the register carried out, the buildings were classified as follows:

1. Buildings with important structural damage
2. Buildings with minor structural and/or non-structural damage
3. Buildings not damaged

Specialists in hazardous materials from the university (MATPEL) helped with the structural evaluation process since certain installations (laboratories and others) must first be cleared and rated as non-hazardous installations with respect to the type of substances stored therein.

2.4.2 Habitability

Habitability is a concept that is related to the perception of security for occupants and the ease of operation of the facilities. This may have been the most difficult concept to agree on given its subjective nature and because the rapid opening of the university required that many installations be cleared for use with simultaneous repairs.

Bearing in mind the objective of starting classes on 5 April 2010, and the habilitation of facilities for staff before this date if possible, we defined the following habitability criteria:

- Category 1. Habitable after repair: the entrance of persons is not authorized.

- Category 2. Habitable with simultaneous repairs: the entrance of persons and use of facilities are authorized in conjunction with the repair program. This concept considered the projected habitability as of 5 April.
- Category 3. Habitable.

The classification was a dynamic concept, and periodic adjustments were made as the repair program advanced. The list of buildings and their habitability ratings were reported to the university authorities every 15 days.

2.5 Effects of the earthquake on the UdeC infrastructure

2.5.1 Effects on the buildings

In total, 141 buildings were found to have some type of damage, as summarized below.

Those buildings constructed in the last 20 years (after the 1985 earthquake) received very little or no damage (classes 2 or 3). Typical problems included the falling down of ceilings, small cracks in brick partitions and walls, and movement in dilation joints between contiguous buildings.

The brick partitions of buildings constructed in the 1960s and 1970s, mainly buildings structured with frames, suffered abundant damage. However, the earthquake-resistant structure of the building remained unharmed. One exception was the Dental School building, which did experience structural damage.

The brick walls of the oldest university buildings (built prior to the 1960 earthquake) were damaged but withstood the earthquake well. These were subjected to a repair program based mainly on the incorporation of elements of reinforced concrete and repairs (or changes) of the confined brick masonry.

Excessively thick stucco, a lack of confinement (buttresses), and inadequate anchoring of secondary elements played a role in the recurrent faults of the buildings.

Three modern buildings erected under the modality of projects with State funding constitute separate cases. Legally, the State is responsible for the administration and technical inspection of these works during construction. All price quotations and material acquisitions for these projects were done using the system “ChileCompra”, in which materials are specified by characteristics and not brand. In reality, these works

suffered several problems such as abundant damage, problems with the use of materials, and a lack of user conformity. Nonetheless, it is important to point out the local commitment to generate a future modality of work in which the user is part of the executive directory of the administration of the work.

2.5.2 Chemical Sciences Building, Concepción Campus

The steel structure of the building of the Faculty of Chemical Sciences was totally destroyed by a fire that

was produced within the building as a consequence of the earthquake.

All the studies done recommended the deconstruction of the building.

2.5.3 Marine Biology Station, Dichato

The Marine Biology Station was destroyed by the tsunami that affected the town of Dichato. This station had a dock, buildings, and a vessel, among others.

Figure 2. Damage to UdeC buildings (TCUDEC, 2010)



Figure 3. Burnt building of the Faculty of Chemical Sciences (TCUDEC, 2010)



Figure 4. Destroyed Marine Biology Station in Dichato (TCUDEC, 2010)



2.5.4 Effects on other infrastructure

Along with the damage to university buildings, other infrastructure was affected, including unpaved roads, paved streets within the campus, paved areas outside of buildings, and service networks. These repairs were not important in terms of amounts or time.

2.5.5 Classification of Habitability

Following the habitability criteria defined earlier, Figure 6 shows the habitability situation of the UdeC buildings on 5 April (the start of classes).

This figure was constructed over a universe of 141 buildings. Quantitatively, the buildings were classified as follows:

- Category 1: 17 buildings (12%)
- Category 2: 75 buildings (53%)
- Category 3: 49 buildings (35%)

Classes began at UdeC on 5 April, 37 days after the earthquake. At that point, 88% of the buildings could be used totally or partially. Priority was given to the habilitation of classrooms for imparting subjects.

2.6 Project Management in the rehabilitation of the UdeC infrastructure

2.6.1 Repair standards

Based on the engineering analysis and the occurrence of similar faults in different buildings, repair standards were defined for each type of damage. This pragmatic, rapid engineering was consistent with the post-earthquake needs. The criterion for repair was to return each structure to its original condition through the necessary strengthening of the areas shown to be vulnerable by the earthquake. In some cases, this condition was even improved.

These standards were transmitted in committee meetings to the administrative engineers of the different repair projects. The engineers and subcontractor companies then used this information to begin the cubage of the buildings to determine the amounts of each contract.

The specifications or repair standards were defined as follows:

- Repair of diagonal cracks in the brickwork elements

- Repair of horizontal cracks in brick walls
- Repair of cracks in frames with brick partitions
- Repair of dilatation joints between buildings
- Repair of cracks in elements of reinforced concrete
- Reinforcement of brick walls
- Repair of pavement
- Specifications for the replacement of partitions, ceilings, windows, paint, and others
- Special repairs following simple engineering details

2.6.2 Structural rehabilitation projects

The structural evaluation determined that only two university buildings (the Dental School building and the main gymnasium) and specific parts of other buildings had structural damage.

According to the standards of Seismic Building Design NCh 433, enacted in 1996 and modified in 2009 (INN, 2009), the buildings of the Dental School and the main gym were moderately damaged. Structural recovery projects were developed by specialized professionals from the Civil Engineering Department and both repair projects consisted of reinforcing the damaged structures. Plans, repair details, and technical specifications were drawn up and qualified technical inspections of the work were carried out under the direct supervision of the structural specialists involved. At present, both buildings are repaired and operative.

A few buildings suffered some minor, localized structural damage that also required specific structural repair projects of less breadth.

In the case of the building of the Faculty of Chemical Sciences, with its burnt metal structure, a deconstruction project was generated.

2.6.3 Economic valuation of the UdeC rehabilitation project

APM (2006) defines estimates as “an approximation of project time and cost targets that is refined throughout the project life cycle”. A series of tools and techniques are used to produce these estimates (APM, 2006). In the particular case of the UdeC rehabilitation project, the best-evaluated construction companies known to the university were convoked to carry out direct deals following the valuation of the works considering the information of habitability and the type of damage to the buildings. To generate the

Figure 5. Damage to other infrastructure (TCUDEC, 2010)



budget per building, an *in situ* meeting was held with a representative of the construction company and the administrator of the contract to inform the construction company representative as to the type of repairs to be done and the repair standards; additional information was provided in the form of sketches and written plans. This was done for all the buildings of the university, resulting in an economic estimate of the total investment to be made.

In summary, pragmatic repair projects were specified based on the experience of the engineers in the UdeC technical group. Due to the urgency of the results, traditional projects with thorough technical specifications, official budgets, and the following call for proposals were not done.

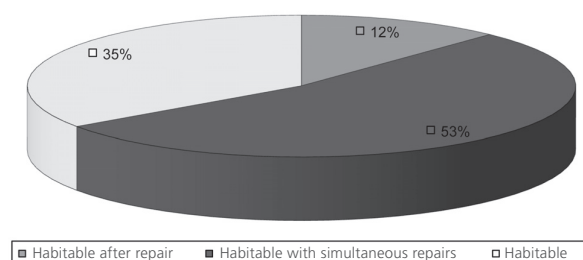
Prior to a direct adjudication, under the modality of a global value with adjustable parts, a study was done to standardize the unitary prices of each part as a measure of the values budgeted per each company.

In a meeting held with the representatives of the construction companies, a single price was established, constituting the basis of a transparent contractual coexistence. This allowed the possibility of replacing contractors at the same contractual price in the future.

Due to post-earthquake logistic problems, mainly with banks, notaries, and others, the adjudication of the contracts was done with very simple protocols, excluding relative clauses regarding fines, bills of guarantees, and others. All the negotiations described were based on trusting relationships existing between the contractors and the university.

This rapid reaction was fundamental since it allowed the university to move ahead of other repair projects that were being generated on the market, thereby guaranteeing the availability of the contractors required for the massive university projects. This was transcendental since, in the days following the earthquake, there was a shortage of materials and limited availability of cash money in the zone, making it necessary that the contractors be committed to the UdeC since they would have to finance the supply of materials and money from other parts of the country that had not been as heavily affected by the earthquake.

Figure 6. Habitability of UdeC buildings as of 5 April 2010 (TCUDEC, 2010)



2.6.4 Repair contracts

Arriagada (1988) defined fast-track contracts as those in which each activity is done at the earliest possible date. Thus, tasks that were previously done in a serial manner can overlap. The design of such contracts does not necessarily end completely when construction

begins. According to this author, these contracts can be used when there is an urgent need to obtain the functioning of installations (Arriagada, 1988), which was precisely the case of the UdeC rehabilitation projects.

Project Management is fundamental with fast-track contracts given the need for efficacious coordination, since the activities are closely related amongst themselves due to the need to move information or resources. The massiveness of the projects, urgency of the repair periods, and type of repetitive damage in the UdeC infrastructure facilitated the implementation of these contracts.

The administration of contracts and technical inspections were done by experienced professionals from the UdeC Direction of Services, and the engineer consultants offered advice as to the structural concepts.

With the consent of the UdeC comptroller, the liquidation of the contracts was done by incorporating an external professional to the administration of each specific contract. At the close of each contract, the parts actually executed were evaluated. In many cases, this implied an increase or decrease of the global estimated value. Along with the closing of the contracts, we completed a statistical spreadsheet with a brief description of the parts, a justification of any higher or lower costs, and an evaluation of the company.

It is important to note that the global sum considered for the rehabilitation of the UdeC buildings included an estimated 10% to cover unexpected expenditures not contemplated in the initial rapid evaluation. Finally, the unexpected expenditures related to increments in contracts did not exceed the percentage initially estimated.

Moreover, since the Project Manager represented both the economic and technical interests of the mandator, his knowledge and experience in engineering were very important as they allowed the Project Manager to concur with the planners in the selection of the best possible solutions, both technically and economically.

2.6.5 Day-to-day Project Management at the UdeC

Particular characteristics of the Universidad de Concepción

According to APM (2006), the organizational structure refers to the organizational environment in which the

project is carried out. In the case of the UdeC project, the Project Manager was able to hire external staff for the administration and inspection of the works. Nonetheless, a decision was made to work only with the staff of the Direction of Services, supported by professors from the Civil Engineering Department. This simple decision was fundamental for the relationships with the users of the university facilities due to the permanent, established relationships of the institutional community. Along with the eminently technical tasks, the professionals of the Direction of Services were key players in what could be referred to as internal UdeC public relationships, particularly in the buildings of category 2 (habitable with simultaneous repair).

Regardless of the above and as a lesson learned, it would have been convenient to have someone in charge of communicational management. This person could have emitted timely communiqués to the university community explaining the extent of the committee's works and dealt with many problems in the field associated with the repairs. Of course, the ideal candidate would have knowledge of the UdeC organizational culture.

Finally, it should be noted that numerous delegations of specialists, professors, graduate students, and other national and international visitors interested in examining the type of damage and repair programs of the UdeC infrastructure visited the works during their execution.

Changes in building habitability classifications

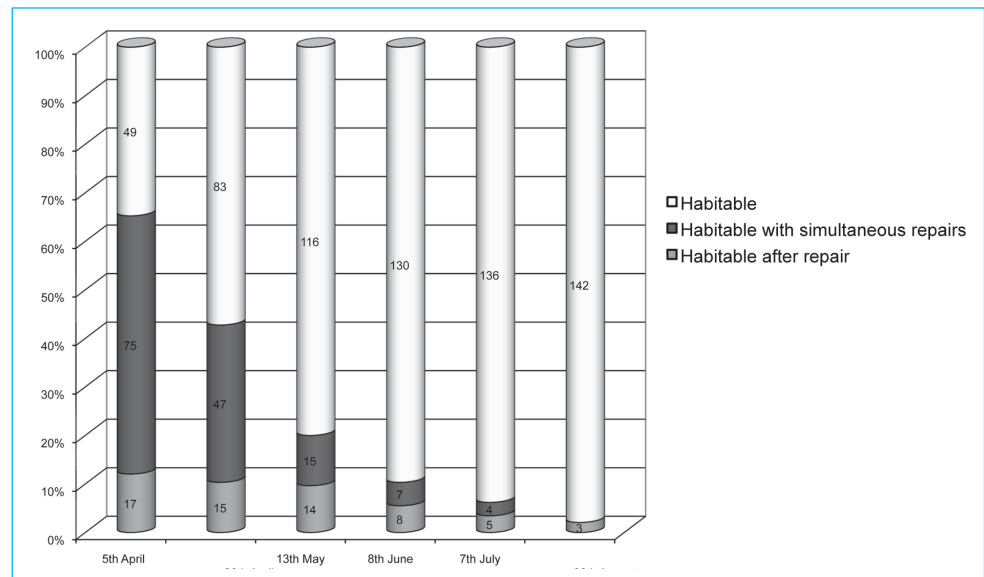
In a certain way, the committee work was reflected in the progress of the recovery projects. As these advanced, the habitability classifications of the buildings were adjusted as shown in Figure 7.

Reports to the mandator

In Project Management, Information Management is the "collection, storage, dissemination, archiving, and appropriate destruction of project information" (APM, 2006). Information Reporting, on the other hand, "takes information and presents it in an appropriate format which includes the formal communication of project information to stakeholders" (APM, 2006).

The mandator of the UdeC infrastructure rehabilitation projects was conformed by what is, in the organic structure of the university, the Rectory and the Corporate Directorate of the Universidad de Concepción.

Figure 7. Habitability of UdeC buildings on different dates (TCUDEC, 2010)



Periodic executive reports informed on the progress made in the habitability of the buildings, works to be executed, due dates, cost summaries, and others. The information management and later presentation of the reports supported the decision-making of the mandator.

Moreover, based on these reports, the Vice Rector of Economic and Administrative Affairs also divulged part of its reports to the university community.

Committee meetings

At first, the full committee met full-time every day in an office set up as its headquarters. After the adjudication of contracts, daily meetings were held to generate reports, analyze cases, and define priorities.

Following 5 April 2010 (the start of classes), the contract administrators continued operating full-time, mainly in the field, and coordination meetings were held three times per week.

The main aspects dealt with in these meetings were:

- Progress reports of the works
- Coordination of the structural projects
- Coordination with users and conflict management
- Discussion of technical solutions

- Changes of contractors and contract administrators
- Pending buildings and/or sectors of buildings
- Continuous motivation of the team, particularly following the initial reaction
- University management

In large measure, the above reflects the daily work of the committee through which the group that began the works was transformed into a working team.

Worker insurance

The earthquake generated strong worker mobility. The university facilitated the purchasing of insurance for all workers that entered into their works through an agreement with a national company. This coordinated action facilitated the necessary formalities of the construction, from which the value of the insurance was deducted when paying the contracts.

3. Conclusions

Considering the background of the case studied herein, in particular the needs generated by a project of the magnitude of that required to rehabilitate the UdeC infrastructure and the particular conditions following the earthquake in Concepción, Project Management was not only applicable but absolutely necessary

for the good performance of the projects and the achievement of their objectives.

In fact, the UdeC rehabilitation projects required the tools provided by Project Management for the definition, planning, supervision, control, and delivery of the works. In this manner, important goals of time and cost such as the habilitation of the facilities for the start of classes were met. Moreover, the initially estimated budget approved by the university was not exceeded.

Given this and the context in which these projects took place, the utility of Project Management was highlighted through the management of massive infrastructure rehabilitation projects following a natural disaster such as the case presented herein. Other Chilean institutions that also needed to carry out massive post-earthquake repair projects considered the model for applying Project Management used at UdeC.

In this type of project, associated with disasters and massive repairs, timely definitions are indispensable. In the particular case of the UdeC projects, these were achieved through the rapid decision of the university authorities to create a Technical Committee and the application of pragmatic engineering that allowed defining repair standards for damage types, technical criteria for defining solutions, and specific structural projects. Moreover, this knowledge and experience in engineering allowed the Project Manager, as a representative of the mandator, to safeguard the university interests from technical and economic points of view, converging on the solution considered to be optimal for each case. This allowed important savings and, thus, the original budget was respected.

The strategic decisions made by the university mandator were supported by the executive reports put together by the committee. These showed the progress made in the habitability of the buildings, works to be executed, due dates, cost summaries, and others.

The fast-track contracts used for the projects required a high degree of coordination since their design was not necessarily completed when the work began, resulting in an important demand for information due to the close relationship between the activities. Moreover, a control of these contracts was carried out, mainly considering an evaluation of the parts actually executed, which meant that the original estimated budget was respected despite the increases and

decreases of the works. Therefore, and taking into account the massiveness of the rehabilitation projects, Project Management was fundamental.

Based on this experience, the contracts generated under a "state of exception" should operate free of the normal bureaucracy and facilitate the steps of contract adjudication and the closing of contracts. The above is only possible if there are solid, trusting relationships among the parties, which there were in this case. Moreover, the success of these fast-track contracts was due to the positive synergy generated in the post-earthquake "state of exception" and the coordination and control performed. Nonetheless, this type of contractual hiring is not recommended for works normally carried out by the university in its typical day-to-day operations.

Having professors of Civil Engineering working on the repair projects was transcendental, since along with the technical knowledge of the specialty, the sense of belonging and commitment to the institution contributed substantially to achieving the proposed objectives.

Knowledge of the UdeC organizational culture on the part of the committee members was fundamental for the success of the project. In particular, the relationships generated within the institutional community contributed to the materialization of technical solutions, especially in the buildings classified as habitable with simultaneous repair.

The experience of the UdeC Technical Committee strengthened the professionals of the Direction of Services. This is important since, given the university structure, they must continue to work together. The members of the TCUDEEC have assimilated valuable know-how, both personally and as a work team.

4. Acknowledgements

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