

SUCCESS AND FAILURE OF INFRASTRUCTURE CONSTRUCTION PROJECTS

THE BRAZILIAN REALITY

WORKING PAPER

BY

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Success and Failure of Infrastructure Construction Projects: The Brazilian Reality

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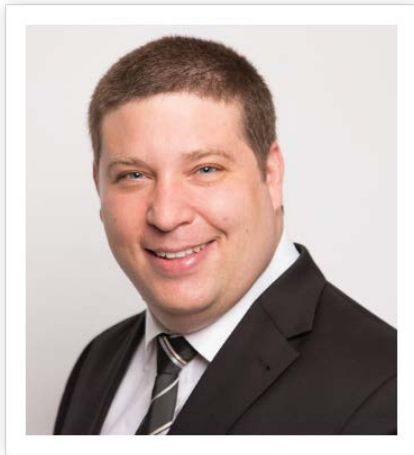
WORKING PAPER

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EXECUTIVE SUMMARY

The infrastructure construction sector in Brazil is ranked as one of the top 10 biggest infrastructure sectors in the world and received USD 321.9 billion dollars of investments in 2015. Independent of the recent country's economic downturn, the infrastructure sector is behaving with resilience since these investments are essentially long-term investments with a conventional 20-year concession period in a public-private partnership scheme.

Economists agree that appropriate infrastructure investments are critical for a country to develop and being able to generate social welfare for its population. As a result, the costs of an infrastructure project failure do not disturb only the investor or the project sponsor but also affects the entire society.

Large construction projects are characterized by the utilization of several transformation processes with intensive labour work, thus sometimes makes it appear that it can be planned, organized, implemented and managed with ease. However, the large number of construction processes that ends up failing reveals the complex nature of infrastructure construction projects. Construction projects are not as predictable and orderly as they appear, since its processes are dynamic, nonlinear and complex what can lead these projects to a complete chaos.

Merrow (2011) measured the failure rate of large industrial projects worldwide and impressively revealed that 65% of these projects have failed and subtracted value from the companies.

The study outcomes revealed that in Brazil the infrastructure construction projects have a failure rate of 62.15% using Merrow (2011) thresholds for failure. The identified main root causes of this high failure rate are equally the lack of proper scope definition, the lack of proper planning and the failure in the cost estimation.

Furthermore, it was detected that professionals coming from the contractor side have experienced more failure and poor performance than professionals that come from investors or designers. This reality is mainly due to the EPC contractual arrangement that contractors are usually submitted, where they cannot transfer the cost overruns to the project owner or have to pay considerable penalties if the project delays.

The main root causes of failure identified can influence the project during its whole lifetime, but the development phase was identified as the phase that most contributes to the infrastructure construction project failure.

Chapter 1. INTRODUCTION

1.1 Background of the Problem

According to BMI Research (2016), in 2014, more than 17,982 billion dollars have been invested worldwide in infrastructure projects and Brazil was among the Top10 destinations for these resources. McKinsey Global Institute (Dobbs et al., 2013) estimates that globally 3.8% of the GDP is averagely spent on infrastructure projects and by 2030, the world will demand an investment of 57,300 billion dollars in infrastructure projects in the sectors of: roads, railroads, ports, airports, power, water, waste and telecom. BMI Research (2016) estimates that by 2025 the investment in infrastructure projects will reach 30,802 billion dollars worldwide, 71.3% more than what was spent in 2014.

Most of the infrastructure construction projects are considered large capital-intensive projects, or megaprojects, and Merrow (2011) have detected a failure rate of 65% in a database comprising for 318 global megaprojects in the fields of power, transportation, oil and gas, mining and industry in between 1990 and 2010. That is, for many years, investors and governments have squandered a large sum of resources, since part of these infrastructure projects have failed and consequently have destroyed the capital of its investors.

This reality is not restricted to the large construction capital projects, The Standish Group (2013) compiles, on a yearly basis, information from failure in Information Technology projects worldwide, and shows that in 2102 18% of all projects are cancelled before they have been even completed. From the completed projects, 43% fail to deliver the expected cost, exceeding in an average 54% the original cost estimates and 74% the time estimates. On the success side, only 39% of the IT projects are completed on time and on budget.

Literature about success and failure of projects is widely available and unfortunately mainly focused on the side effects of a failure, which they often call “causes of failure”, then answering the following question on a strategic level: Why are projects failing so often?

This paper has the aim to investigate if infrastructure construction projects in Brazil are failing more often than being successful and answer what are the root causes

of this failure by investigating its causes in a strategic level of the organization in order to support the business leaders to build successful enterprises.

1.2 Background of the Study

“Frustration!” This is the most common feeling before, during and after the execution of an infrastructure construction project and failure is highly attached to it.

Despite of being one of the oldest activities of humankind, construction projects are often surrounded by initial excitement and late disappointment, especially when dealing with landmark projects that will support the country’s future development. The cases are public and often reported by the media. As an example, it is possible to mention the Channel Tunnel that provides a railway link between the UK and France, Three Gorges Dam in China, the biggest hydroelectric project in the world, Great Belt Fixed Link, a logistic link between the islands of Zealand and Funen in Denmark or even the Boston Big Dig, a tunnel project that rerouted the Interstate 93 in Boston, Massachusetts. All these infrastructure projects have a common denominator, they are in operation, they have been built with a safe and competent design, they are serving millions or even billions of people annually, but they experienced problems in a billion of dollars’ range regarding to cost overruns as shown in the Figure 1 below.

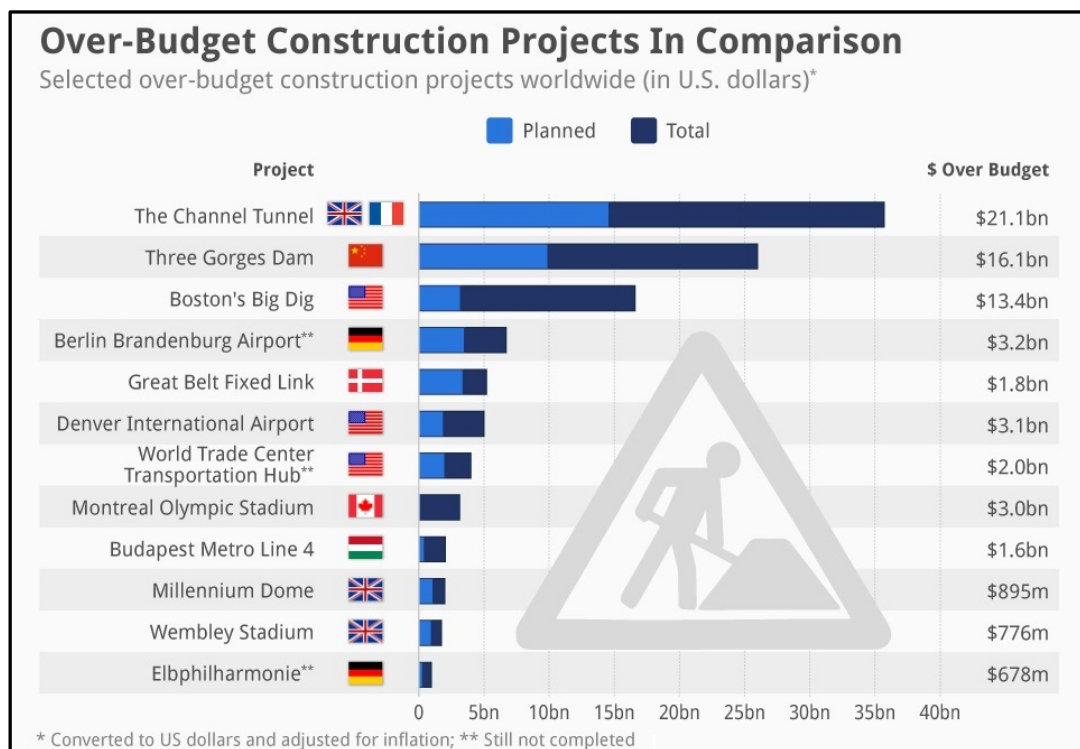


Figure 1 – Over-Budget Construction Projects Worldwide (Statista Website)

This study will focus the infrastructure construction projects in Brazil and aims to understand the failure rate of this type of projects and the root causes of it.

Brazil, during the last 7 years, has been responsible for 2% to 3% of the global infrastructure investment (BMI Research, 2016) being one of the countries in the Top10 list of investments in this sector.

The Figure 2¹ presents the Top10 countries ranking of infrastructure investment from the year 2009 to 2015.

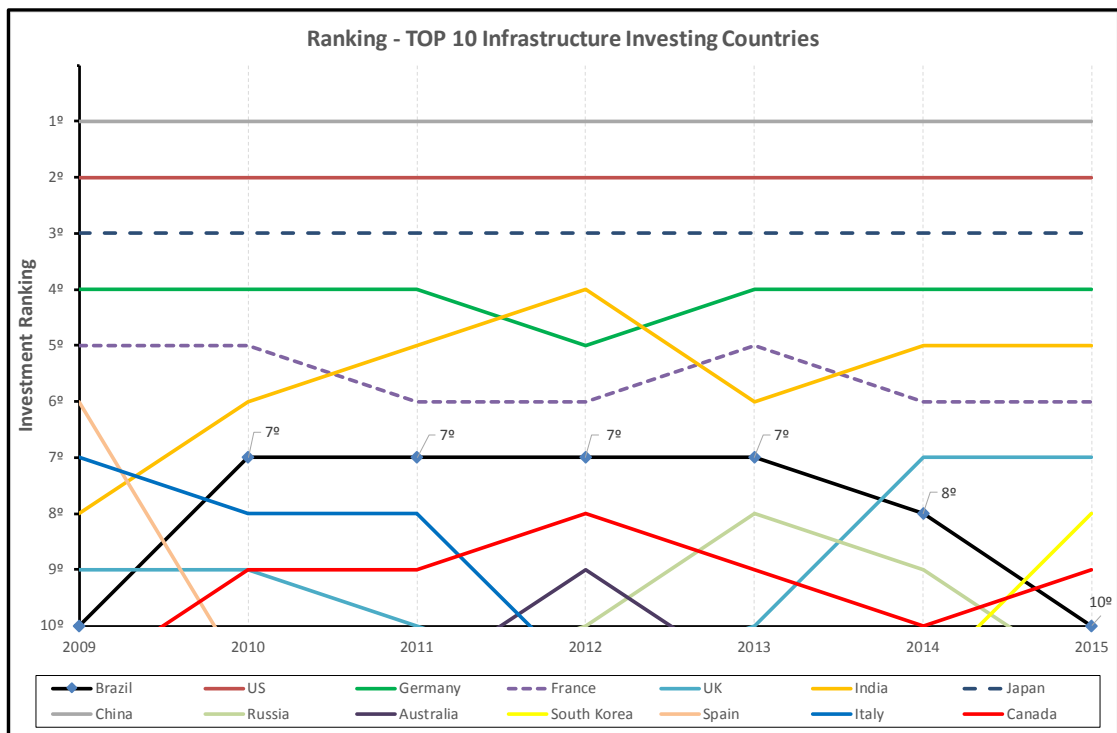


Figure 2 – Ranking of Investment in the Infrastructure Sector

Brazil is known to be the Latin America’s largest economy and part of the BRICS, the five major emerging economies. The country has a large experience with Public-Private Partnerships, the PPPs, and today, according to World Bank Group (2016), Brazil has 770 active PPP projects and most of the infrastructure projects in the country are developed, executed and operated through such vehicle.

Independent of the recent downturn in its economy and being officially under recession since Q32015 due to the perfect storm framed by a profound political crisis, low commodity prices and the biggest corruption scandal in history (“Brazil’s crisis Irredeemable?”, 2016), the infrastructure investments are behaving with resilience to

¹ Data retrieved at BMI Research (2016)

the situation and has the potential to be one of the responsible to move Brazil out of the economic crisis.

The reason and the main driver for the investments are the PPP contracts signed between the Brazilian government and private investors in the last years and the long-term view of this type of investment.

Figure 3² compares the total infrastructure investment in all Latin American countries and the total infrastructure investment in Brazil.

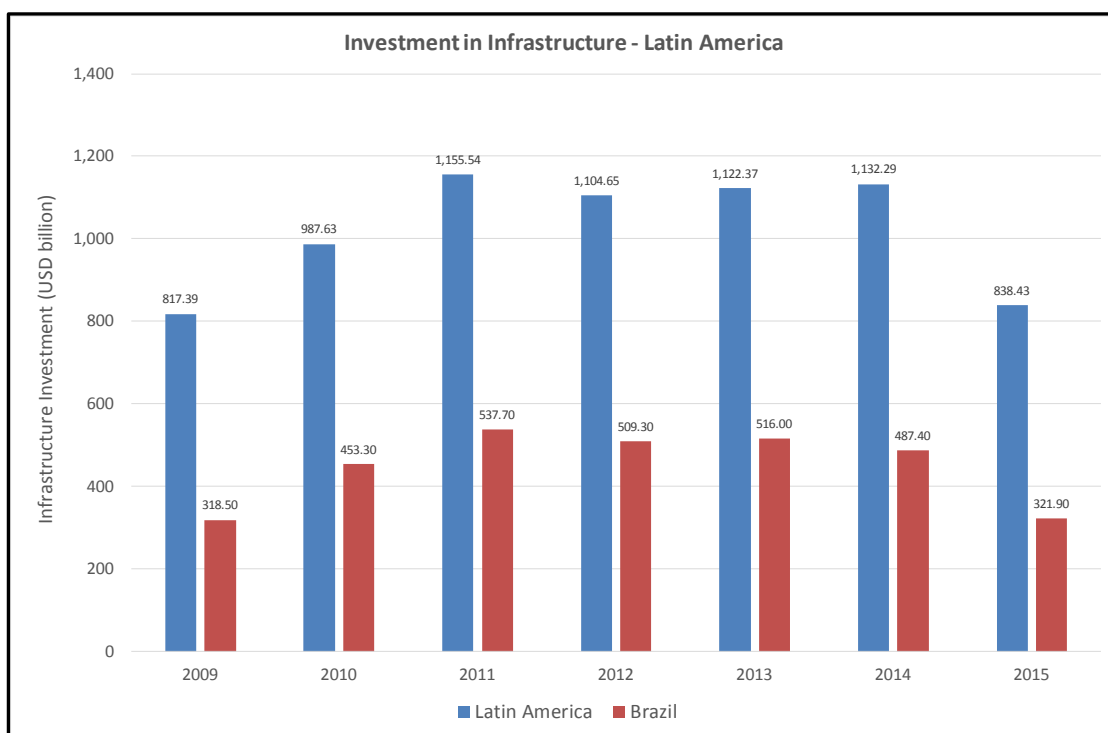


Figure 3 – Comparative Infrastructure Investment in Latin America and Brazil

Despite of the strong investment flow in infrastructure during the last decade, a major concern to businesses entering Brazil is still the inadequate logistics infrastructure. Brazil's ports are underequipped and overburdened, leading to congestion and severe delays in the flow of trade goods. Its rail system is similarly underdeveloped, forcing companies reliant on freighted goods, or involved in the logistics of supply chains, to rely almost entirely on poor quality road networks. This leads to extensive delays and high costs, as chronic congestion and limited road connections to northern and central regions slow supply chains. Additional structural problems come from overreliance on hydropower generation and a consequently erratic electricity supply, which, in conjunction with the poor water availability in many areas,

² Data retrieved at BMI Research (2016)

can lead to water shortages and power cuts. These issues are mitigated to some extent by lower fuel and electricity prices, good connections to international air and sea shipping routes, and strong internet services. (“BMI View - Brazil - Q2 2016”, 2016)

The Global Competitiveness Report 2015-2016 of the World Economic Forum (Schwab & Sala-i-Martin, 2015) presents the ranking of the 140 countries regarding to its infrastructure. The ranking is given in a scale that ranges between 1, underdeveloped and 7, extensively developed according to international standards. In the first positions, it is possible to find Hong Kong (6.7), Singapore (6.5), Netherlands (6.3), UAE (6.3), Japan (6.2) and Switzerland (6.2). The last positions are occupied by Chad (1.7), Guinea (1.8), Madagascar (1.9), Haiti (1.9) and Burundi (2.0). Brazil actually occupies 74^o place, scoring 3.9, what is a low-intermediate position below countries like South Africa (4.1), Namibia (4.1), Mexico (4.2) and Morocco (4.3).

In a situation of an underdeveloped infrastructure, extensive commodity exporting potential, continental size, 1% per year of population growth (World Bank Group, 2016) and a recent downturn in its economy, Brazil has the challenge to take the maximum of each dollar invested in the infrastructure sector and this is what this study wants to address by sizing the problem, with an understanding of the actual failure rate of this type of project and listing the root causes of these failures.

The study of the subject is divided into two parts, the first part is a secondary research using the available literature on the researched topic and the second part is a primary research in order to answer the specific questions raised.

As an initial point, for the secondary research, a definition for the term “infrastructure construction projects” will be provided also an understanding of the construction business and the PPP model and the Brazilian infrastructure sector.

A literature review will also be performed to study what authors are considering as failure or success in such or similar projects and if success and failure are complementary events or not. Together with the success and failure definitions, will be researched the causes of these failures focusing on the root causes not in its side effects since the root causes could be addressed through a strategic change in the company and will provide a long-term return.

In the primary research, an online questionnaire will be applied to engineering and construction professionals, able provide an expert opinion regarding the failure rate and its causes. This primary research will end with a statistical analysis of the responded questionnaires with the proper comparisons.

Following these actions, the study will be summarized through an overall conclusion followed by the recommendations, ethical implications of the findings and the learning aspects of the research.

This study also aims to discuss what is the level of information required for managers and directors to formulate an investment decision in infrastructure construction projects in Brazil.

Chapter 2. OBJECTIVES OF THE STUDY

2.1 Problem Statement

The Brazilian infrastructure market is one of the largest in the world and despite of the recent economic downturn the investments, mostly made through Public Private Partnerships, are happening and generating economic and social benefits.

According to PWC report, 19th Annual Global CEO Survey, (Nally, 2016) that researched 1,400 chief executive officers around the world about their impression of investment perspective in countries underdevelopment, concluded that:

“CEOs continue to see investment opportunities across the BRICs, despite the complicated picture they present.”

In this same report, the item adequate physical and digital infrastructure are the second major concern of CEOs only behind of a skilled, educated and adaptable workforce as presented in the Figure 4 below.

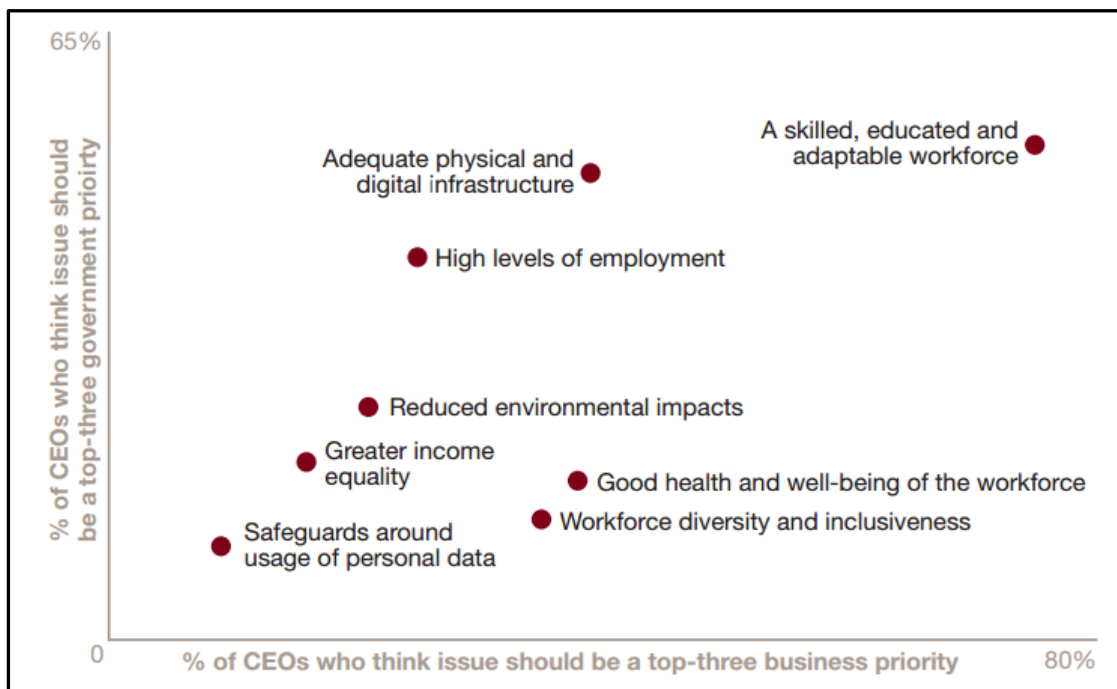


Figure 4 – Major BRIC Issues According to CEO’s Research (Nally, 2016)

As Merrow (2011) presented, large construction projects tend to have a high failure rate, around 65%, according to his definition of failure what lead investors to lose an enormous amount of money and tight or even derail its infrastructure projects.

Brazil is not far from this reality, but there is no literature available that had measured this failure rate for infrastructure construction projects in the country or even presented its root causes.

The costs of an infrastructure project failure do not affect the investor or the project sponsor alone, but also affects the entire society since this is an asset highly connected to several social needs, for instance, water treatment, hospitals, sewage system, telecommunication systems, power plants, roads, etc.

Henckel and Mckibbin (2010) reported that most of the economists admit that proper infrastructure investments are imperative for a country to industrialize and being able to generate social development for the population. Analysing this topic from a development perspective, investments in infrastructure projects offers mainly two benefits. Firstly, it is able to raise the productivity and reduces the cost of goods produced by the private sector and secondly, it has a large effect on the income and welfare of the people by reducing the logistic costs, raising the investment returns of existing assets and other economic benefits, especially among the poor ones. Calderón, Moral-Benito and Servén (2014) have estimated the returns of investing in infrastructure by measuring the elasticity of the country's GDP to the infrastructure asset value of the country. The elasticity value lies in between 0.07 and 0.10, what means that each 10% rise in infrastructure assets directly increases GDP per capita by 0.7% to 1.0%. In addition, The World Bank reports that approximately ten percent increase in infrastructure assets impacts a rise in the gross domestic product (GDP) to a range of one percentage point (Frese, 2003).

Therefore, it is fair to say that the lack of understanding of the failure rates of proper delivery the infrastructure construction projects and its root causes, affects the country competitiveness and the potential to attract and retain business and bounces to the population's wealth, especially the underprivileged ones.

2.2 Objectives of the Study

The primary objective of this study is to understand the failure rate in infrastructure construction projects in Brazil. Because of that, failure condition for this type of project shall be clearly defined first and supported by the literature.

After identifying the failure rate, it is possible to search the causes of this failure in order to investigate the root cause(s) that are contributing to this situation.

Based on the information collected at BMI Research (2016) about the infrastructure investment yearly by country, it is possible to predict the level of waste of economic resources in this market.

2.3 Hypothesis Statement

Subsequently the research on the failure rate of infrastructure construction projects in Brazil, the following hypothesis statement will be investigated:

H₀ statement: Infrastructure construction projects in Brazil have a failure rate below or equal to 50%

H_a statement: Infrastructure construction projects in Brazil have a failure rate above to 50%

The reason for setting up the failure rate threshold of the infrastructure construction projects in Brazil at 50% in the null and in the alternative hypothesis is the random walk principle according to which two outcomes are equally possible in the research sample, success and failure, and we wish to investigate if there is a prevailing tendency in the sample researched. This approach helps to guarantee an unbiased approach regarding to the outcomes of the primary research.

2.4 Additional Research Questions

Besides the hypothesis analysis, this research also aims to understand what are the main root causes of failure of infrastructure construction projects in Brazil.

In addition, the research aims to segment the targeted population into relevant groups in order to understand if these groups have different understanding of the main root cause of failure.

The segmentations proposed for the root causes of failures of infrastructure construction projects in Brazil are the following:

- Question 6 – Type of Respondent's Company

Furthermore, the failure rate will be also researched among segmented groups in the target audience in order to determine if these segmented groups share the same experience regarding to unsuccessful projects. Equally important the project data will

be segmented as well into subgroups inside the infrastructure construction projects to check if these sub-grouped projects have the same failure rate as general infrastructure construction projects in Brazil.

In summary, the proposed segmentation for the failure rate proportion is the following:

- Question 2 – Segmentation by Position
- Question 6 – Type of Respondent’s Company
- Question 8 – Type of Infra Construction Project

2.5 Limitations

Success and failure in projects is a vast subject with an enormous interpretations and correlations. Despite of some projects fail in some aspects and succeed in others, this study will treat success and failure as mutually exclusive events, so if there is success, there is no failure and vice versa. This approach is based on Merrow’s (2011) observations regarding to large construction projects worldwide, where these projects tend to be successful and fulfil all stakeholder expectations or fail miserably, bringing a negative net present value to the investor and huge losses to its service providers. The amount of projects that fall in between of these two conditions, or in other words, in a grey area between success and failure, is very limited for projects with sizeable CAPEX³, which is the case of infrastructure construction projects.

The scope of the study will also be limited to infrastructure construction projects in Brazil and for this reason; residential, commercial and industrial projects worldwide will not be part of the investigation, neither infrastructure construction projects in other countries.

³ Capital Expenditure, or CAPEX, is the total investment made in a project from the beginning up to the operations phase.

Chapter 3. LITERATURE REVIEW

3.1 Introduction

The Online Etymology Dictionary (2016) describes that the word “infrastructure” began to be used in the English language around of 1887 and comes from French with an original meaning of “the installations that form the basis for any operation or system”. According to the Oxford English Dictionary (Stevenson & Waite, 2011) infrastructure is the “basic physical and organizational structures (e.g. Buildings, roads, power supplies) needed for the operation of a society or enterprise”.

PMBOK (Project Management Institute, 2013), the project management body of knowledge, defines “project” as a temporary endeavour to make something unique. Temporary means that this endeavour has a defined begin and an end.

Consequently, an infrastructure construction project is a project dedicated to building the basic facilities needed for the operation of the society. These facilities can be specified as:

- Logistics and transportation:
 - Ports;
 - Airports;
 - Roads;
 - Railways;
 - Waterways and canals; and
 - Pipelines.
- Power:
 - Power plants;
 - Transmission lines;
 - Distribution lines; and
 - Substations.
- Telecommunications:
 - Electronic infrastructure; and
 - Non-electronic infrastructure.
- Hydraulic:
 - Water systems;
 - Sewage systems;

- Drainage systems;
- Irrigation;
- Sluice; and
- Reservoirs.
- Urban Buildings and Other Systems:
 - Public buildings (schools, hospitals, municipal administration, concert halls, sport stadiums, cultural centres, day care, etc.);
 - Parks and sports facilities;
 - Division and retaining walls;
 - Prisons;
 - Gas distribution system;
 - Heating distribution system;
 - Solid waste collection and disposal; and
 - General urban infrastructure (parking, cemeteries, monitoring system, street lighting, poles, etc.).

In summary, this type of facility is meant to improve the living standards of the society and because of that is one of the most important asset classes that affects the country's wealth. As a result, failure and success of these projects highly influence the nations' status quo.

Inadequate or underdeveloped infrastructure sector contributes to the primary challenge for economic prosperity as well as social enhancement of the population. For instance, Brazil development is challenged by a number of factors such as constricted roads, absence of railways in the additional agricultural areas as well as ports that are bottlenecked.

Infrastructure projects are very critical for governments and infrastructure enhancement as well as investment pipeline is a big deal. Wealthy economies also have important infrastructure arrangements, for example, Britain, in 2011, has initiated an infrastructure pipeline that constitutes of over five hundred projects that are estimated to cost over £250 billion.

A large number of infrastructure projects are known to experience challenges such as expense overruns, delays, lack of procurement as well as lack of private monetary aid (McKinsey & Company, 2013). The last expense of the famous Eurotunnel that is to be constructed between the United Kingdom and France, for

instance, was relatively higher as opposed to the original arrangements. Similarly, the Betuwe cargo railway that connects the Netherland to Germany was estimated to have a cost that was double the first €2.3 billion cost and four times the first cost originally planned.

It is important to acknowledge that these challenges not only occurred in the past but also happen today. Currently, for example, the development of Kuala Lumpur's additional airport terminal is experiencing challenges such as large expense overruns as well as critical delays, particularly after many design iterations (McKinsey & Company, 2013). The majority of these challenges are obvious, foreseeable, happen due to the absence of professional, and risk anticipating management. According to McKinsey & Company (2013), at the present time, the loss caused by under management of large projects can do beyond \$1.5 trillion for the duration of the next 5 years. This is exclusive of the loss because of GDP growth, reputation as well as societal impacts.

These failures show that normally large infrastructure projects experience huge under management challenges in all levels of the value chain as well as the entire life cycle of the project. Particularly, ineffective risk analysis as well as risk allocation not executed properly during the development phase in the initial project stages contributes to higher chances of experiencing challenges and finance shortage in the later stages of the project.

Risk is also not focused on the later levels of the project execution and hence poses as a threat to the share of the project's value (McKinsey & Company, 2013). The majority of project managers usually do not observe that the challenges created in a particular stage of the project can contribute to huge challenges in the later stages. Moreover, the designing and delivery of the current infrastructure projects is very challenging when compared to other type of projects. The long-term elements of these projects need an arrangement that effectively indicates the challenge and a large number of risks that the project is likely to experience in its entire life cycle.

3.2 Success and Failure in the Construction Sector

The construction industry is the centre of most business activities since all other business organizations require a location and shelter for their operation. It is the role of the construction industry to provide the shelter and the location of other industries (Hughes, Williams & Ren, 2012). However, the modern day construction industry faces

many constraints that may have a direct impact on the success of a particular construction project.

Humans have heavily invested in construction projects since the beginning of the civilization and, as a result, the construction industry has evolved significantly ever since. Some of the magnificent construction projects in the ancient times are among the world's most valuable assets. Examples of these architectural marvels of the ancient times that are now part of the world's history include the Great Wall of China, Eiffel Tower in Paris and the Pyramids of Egypt. In the 1980s, the construction industry grew tremendously worldwide and was valued at 1.5 trillion dollars (Li, 2009). During this period of revolution in the construction industry, the growing numbers of buildings, irrigation works and dams clearly indicated that the industry had a bright future. The growth of the construction industry has never slowed down since then. It is estimated that the construction industry grows by over 4% annually. The construction industry is dynamic and just like other industries; it changes with changes with time. The construction industry is characterized complexity in process, length duration of work and the involvement of people from different fields of specialization. The construction industry occupies a prominent position in the economies of various countries (Li, 2009). For instance, the industry is responsible for the fast growth of countries like the US and China. In many cases, high level of construction in a country is usually associated with large infrastructure projects and consequently with a high level of prosperity. The construction industry has a fine line between success and failure. A construction project can be either successful or unsuccessful and the evidences of successful and unsuccessful construction projects are present in every part of the world.

The orderly and linear nature of the construction process makes it appear as a process that can be planned, organized, implemented and managed with ease (Alzahrani & Emsley, 2013). However, the large number of construction processes that ends up failing reveals the complex nature of construction. The construction process is not as predictable and orderly as it appears. It is a dynamic, nonlinear and a complex process that leads to chaos at times. According to some studies, most construction projects end up failing. Failures in construction process come in the form of delays, plan failure and cost overruns (Hughes, Williams & Ren, 2012). Most stakeholders of the construction process only consider a project successful only if it obeys the three principles of time,

cost, and specification that PMI⁴ used to refer as the “triple restriction”. However, according to the last editions of the PMBOK, this definition does not completely embrace all the factors that lead to or result from the project success or failure. In construction project management, success refers to the delivery of the project within the specified budgets, deadlines, and functionality or specifications ("At projects under construction", 1974). It must meet the expectations of the shareholders by being able to perform the intended function. On the other hand, a project is considered a failure if it does not satisfy the needs of the investor or when not completed within the set budget and timeframe. In most cases, time and cost over are tolerable. Time and cost overrun are tolerated with the hope that the project will finally satisfy the needs of the shareholders (Doloi, 2013). Project managers shall, therefore, have a proper understanding of project failure and success. In addition, project managers should understand all factors that can contribute to the success of the construction project and those that can lead to failure.

Failure and success of a construction project are due to lapses in one or more stages of the development and construction processes. A construction project is a temporary work executed with an aim of generating a particular construction product. Every construction project has a beginning and an end. The end is the stage of the construction project where the goals of the project have been accomplished (Li, 2009). Various professionals do the many activities in the process. These people must work within the stipulated period and budget to achieve the goals of the construction project. Construction project involves sub-processes such as designing, feasibility, permitting, bidding, pre-construction, and post-construction. Those participating in the construction must be conversant with the construction process (Lam, Chan & Chan, 2008). There are very many players in the construction process. If players at a certain level of construction do their work unprofessionally, there are high chances that the project will fail. However, if they are professional, the construction project tends to be successful. The stakeholders in a construction project are divided into two main layers, the primary and the secondary layer. None of the layers are autonomous ("Successful Criteria for Sustainable Large-Scale Infrastructure Projects in China: Construction practitioners' perspective", 2013). The most important stakeholders in the construction project are designers, contractors, and investors. They occupy the primary layers of the

⁴ Project Management Institute is the world's leading not-for-profit professional membership association for the project, program and portfolio management.

construction project. They provide all the services required to achieve the goals of the project. The secondary players are the ones that implement the construction process. The secondary stakeholders are further divided into three groups. The first group includes the material suppliers, subcontractors and equipment vendors. The second group includes the building code officials, the insurance companies and labour unions. The third group, on the other hand, includes the federal governments, the local government, the banks and trade organizations (Hughes, Williams & Ren, 2012). The layers and the groups inside the layers are presented in the Figure 5 below.

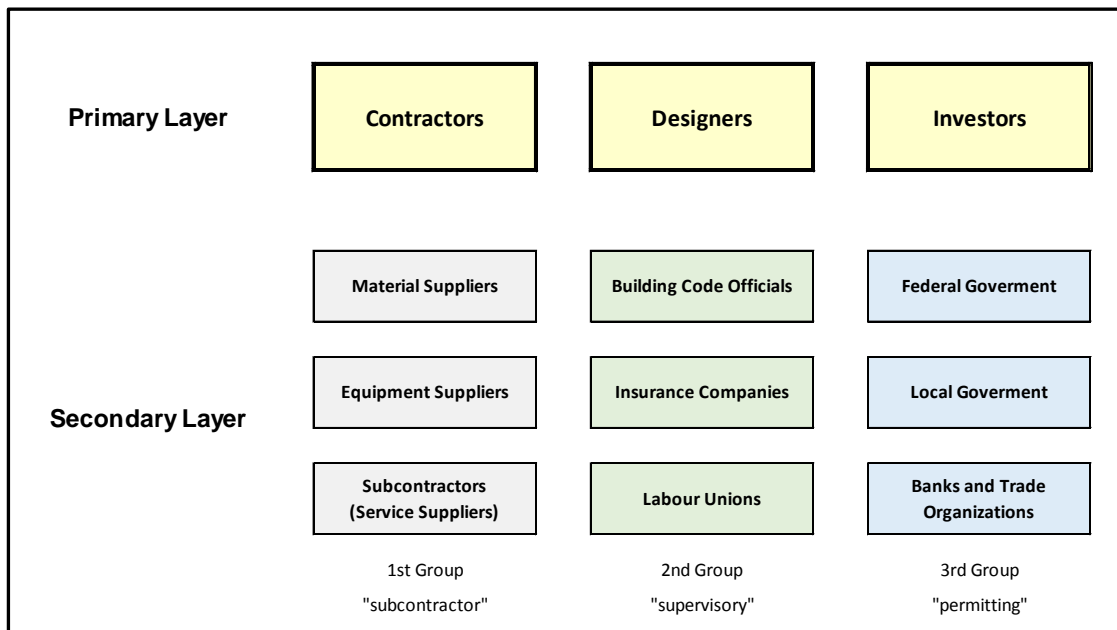


Figure 5 – Stakeholders in a Construction Project

All entities in the primary layer are directly or indirectly connected to all entities present in the secondary layer, but it is possible to identify close working relationships. The first group in the secondary layer, the “subcontractor group”, works closer and is more related to the Contractors entity, since this group tend to execute activities and supply products on behalf of the contractor. The secondary group of the secondary layer, the “supervisory group”, despite of its close relationship with contractors are also closely related to the Designers, since it is the group that tend to minimize the risks to the society by supervising the works that are being executed. The third group of the secondary layer, the “permitting group”, and has the power to authorize or not a project to start or keeping the construction ongoing. This group is more related to the project owner, or the investor entity.

If a project has to succeed, all these groups must work together in a coordinated manner since the development phase of the construction project. Since the 1990s,

researchers have been busy finding out the factors that may be responsible for the failure or success of the construction projects (Hughes, Williams & Ren, 2012). Although there was reserved knowledge of the field in the 1990s, the literature of the time exhibits many similarities. In the 1990s, researchers seemed to agree with the fact that, failure in most projects were a result of the poor definition of goals, scope, and managerial issues. Besides, researchers noted that the success of a particular project greatly depended on communication, teamwork and leadership skills. The three have a direct impact on the project objectives.

The construction project failures can be classified into two groups. These are the managerial and financial failures. It is assumed that failures occurring in certain stages in management are due to management deficiencies. Project management refers to the application tools, skills, knowledge and techniques to activities in a project with the aim of achieving the set objectives. For a construction project to be successful, project management must integrate and appropriately apply project management processes which include planning, initiation, execution, control and closure. Project management, therefore, must identify the goals and the requirement of a particular construction project and address all the needs of the project (Li, 2009). It also involves carrying out and maintaining communication between different stakeholders, balancing constraints and creating project deliverables. All factors that construction management requires are correlated. This means that if one of the factors is changed, the others too must change. For example, if the project timeline is shortened, additional financial resources will be needed to complete the project in a shorter period. Failure to carry out construction project management in the right way is therefore expected to lead to project failure. Many project management issues may lead to the failure of a project (Li, 2009). One of these issues is scoping. At times, the project team is not able to achieve the scope and milestones. At other times, the scope of the project may have changed during the execution of the project leading to confusion. In such a scenario, the work breakdown structure does not reflect the manner in which the project will be delivered. Therefore, the project plan ends up irrelevant. Project failure attributed management failure can also be due to hiring an inexperienced team and poor estimations. In fact, hiring an inexperienced team is one of the main causes of the failure of construction projects. Estimation, on the other hand, requires much experience. In planning, both time and costs are estimated. Poor estimation leads to wrong expectations and consequently project failure. Low level of experience, for instance,

can lead to poor estimation. Some construction projects fail due to the poor risk management. Proactive risk management should involve developing a risk register and controlling it. In addition, it should involve other stakeholders in risk management. This helps the stakeholders know what they might be not be doing right in the execution of the project (Pan, Zhang & Yang, 2010). The projects also fail due to the development of unrealistic schedules. Most of the construction management companies create unrealistic schedules with an aim of winning contracts and keeping their workforce occupied and employed. Unrealistic schedules may also result from political pressure. In other cases, the contractors may have a shortage of tools required to deliver the project leading to construction project failure. The second type of failure is in a project is known as the financial failure. Financial failure occurs when a construction project requires an extra cost to complete. Most construction project ends up requiring the additional resources. The additional costs are known as the failure costs. Most scholars define failure costs as extra costs in project management that could have been avoided if the plans were executed perfectly. Financial failure results from the failure to achieve certain milestones in a construction project (Zablotsky, 2005.). A number of studies have suggested cost that financial failure in construction project management results from design errors, poor planning, poor risk management, construction deficiencies and poor communication between the stakeholders. Though the financial failure rates in construction projects are very high, most construction companies are not aware of the root and nature of the failure cost and how to control them (Pan, Zhang & Yang, 2010). The increase in the rates of failure and construction project cost may at times lead to the failure of the construction companies. A failed construction company affects the business community because the investors, creditors and other stakeholders of the construction project feel the impact of the failure (Pan, Zhang & Yang, 2010). Due to the high rates of failure in the construction industry, it is more vulnerable to bankruptcy than most industries in the world.

Although it is difficult to achieve a high percentage of success in a construction project, the failure factors in a project can be reduced in a number of ways. First, a high level of project management should be developed. A high-level project management consists of experienced individuals who have taken part in other successful projects (Zablotsky, 2005). The owners of the project together with the contractor should be involved in the planning and design processes to ensure that the plan lacks any designing conflicts and defects. Every stakeholder must also appreciate the role played

by project management and make an effort to make things runs as per the stipulation of the project management team. Secondly, as in any other engineering sectors, learning from the previous mistakes could of help in trying to prevent failures in the construction process. In other words, all those involved in the construction process should have a high degree of failure literacy. Failure literacy imparts knowledge on various risks in a construction project to the stakeholders ("Socialist competition in action; at target construction projects", 1974). According to some scholars, the failures expected in the construction companies should be introduced to engineers when they are in their colleges. In America, failure literacy is taught to young engineers with the aid of the American Society of Civil Engineering. The lessons learned from the previous failures in a construction project should be put into action. This means that engineers shall apply these lessons learned of other projects that have failed into their projects in order to achieve better results. However, they should do this in a highly controlled setting since all projects by definition are unique otherwise it will be a routine, not a project. These lessons learned provide more information to the engineers and stakeholders and more information on a specific type of project failure can be essential to develop strategies on how to avoid such failures in the future ("Successful Criteria for Sustainable Large-Scale Infrastructure Projects in China: Construction practitioners' perspective", 2013). Each failure in a construction project points out a gap in the management process of this project both in practice and in theory. Therefore, it is vital to carry out investigations on these gaps to identify the causes of failure. This is the best one in a tightly controlled ongoing project. The results from the ongoing project can be compared to the reports of the previous failures to point out the difference that led to the success in one (the controlled) and the failure in the other.

No agreement or consensus has ever been reached on the best way of managing massive construction projects, like infrastructure construction projects, that are both dynamic and complex towards achieving a successful construction project. This is because the construction environment changes with time and has many activities both planned and unplanned. However, scholars agree to reduce these uncertainties may help overcome the challenges that face the construction projects. The uncertainty may lead to failure in projects in one way or the other (Zablotsky, 2005). It is important for construction companies to develop ways in which they can measure their level of success or failure. In measuring the success of a project, it is vital to distinguish between project management success/failure and construction project success/failure.

Construction project success refers to measurable achievement observed only after the completion of the project. Conversely, project failure refers to measurable failures only after the completion of the construction project. In other words, project success describes the effects of the product of the construction process (Hughes, Williams & Ren, 2012). Therefore, some scholars would want to incorporate the success of the product or failure when measuring the success of a construction process. For instance, if a building might have been considered a failure on its completion, but after its completion, it becomes a successful, it may be considered as successful. On the other hand, project management success refers that which is measured as the construction process progresses. It is looked in terms of timeframe, cost, and quality. Keeping this in mind, successful project management does not always lead to successful construction projects. Similarly, a construction project may end up being a successful product even if the management process was a failure ("Socialist competition in action. At target construction projects", 1974). However, other scholars argue that project management and project success go hand in hand. According to the scholars with this line of thought, a successful project management results in a successful construction project. The success or failure of a construction project should be measured by considering whether the project achieved its goals and not considering whether the product of the construction achieved the goals intended by investors. Therefore, it is clear that people choose to define project success depending on their preferences. The evaluation of project success is important to project managers and the investors. Other stakeholders may also want to know how successful a project they invested their efforts in was.

Many criteria can be used to gauge the success or the failure of the project depending on preferences that the stakeholders have. Project success criteria refer to a set of principles and standards used to measure the success or the failure of a construction project. It some that the failure or the success can be compared or measured against. It compared the performance of the project against the overall goal of the project. Historically, the popular Iron Triangle, or the triple constraint, has helped project managers and investors to measure the success on the failures of their project (Hughes, Williams & Ren, 2012). The Iron Triangle is still used in the modern day as the foundation for measuring the success and failure of conduction projects. However, scholars agree to the fact that the Iron Triangle omits some important aspects that can indicate the success or failure of the projects. For example, the iron triangle fails to measure how well the clients use a construction project product. Therefore, a project

may end up being considered unsuccessful while it is successfully serving the needs of the clients. Consequently, researchers have developed new criteria for gauging the success and failure that incorporates almost all the aspects that can indicate failures or success. The best criteria should consider the views of all the stakeholders, including the managers, clients, workers, contractors and end users. Some of the criteria that should be used in measuring the success or failure of the project in addition to those of the Iron Triangle include safety and legal concerns and professional satisfaction. These criteria apply to any project (Hughes, Williams & Ren, 2012). According to these criteria, a successful project should be profitable, accomplishable, and able to produce a successful product. Similarly, a successful construction project should be politically, socially and environmentally acceptable. On the other hand, a failed project ends up with losses and political, social and environmental unacceptability. The measurement of the success and failure can also be taken from the micro and macro point of view. The micro criterion measures the contractor's performance in achieving objectives such as quality, cost, time, quality and safety. On the other hand, the macro criterion measures aspects such as management, economics, utility, satisfaction, operation, location, and prestige.

Therefore, the available literature suggests that the success of a particular construction project depends on how well the stakeholders play their roles. However, the literature notes that the project management has the greatest role to play in determining whether a construction project will end up a success or a failure. The construction project management must ensure effectiveness in communication, coordination, control, troubleshooting, estimation and scheduling to ensure the success of the project (Pan, Zhang & Yang, 2010). Failure to do this may result in a failed construction project. At of the project, the success or the failure be measured using the available criteria. A successful expectation fulfils the needs of the investors. A failed one may satisfy the needs of the investor, but at an extra cost or after a longer duration. The usability and safety of the product of the construction project can also be used to measure the success of a construction project.

3.3 Infrastructure Projects Ownership

The government and the private sector can own infrastructure assets. Infrastructure when owned by the government can also be operated and developed by the private sector. Companies in the private sector are more interested in the

development of the construction projects and its implementation. The management of infrastructure construction projects involves planning, coordination and controlling projects up to the time they are completed and it is aimed at producing financially viable projects (Freeman & Warner, 2001).

For a long period, the private sector has been involved in the development of the infrastructure and its maintenance. Public private partnerships, or PPPs, have; however, gone past traditionally used contracting of the private organizations. A PPP arrangement often gives the private sector control of the facilities being developed for a long time before it is handed over to the to the public sector on expiry of the contract period (Henderson, 1999). The infrastructure construction projects are developed by the private sector by use of this type of partnership. The private sector takes up a huge amount of risk which otherwise would be taken by the public sector. The private sector exchanges this responsibility for substantial control of the delivery of the services. The major features of this partnership include; the sharing of responsibilities and risks, the public sector retaining mostly dominant duties while the private sector takes up the implementation tasks; maintaining a contractual relationship that is long term (Mourougane & Pisu, 2011).

One of the main aims of PPP is to hand over duties and obligations to provide infrastructure to the private sector and consequently achieve cost reliability, efficiency and financial security. The customary purchase of public infrastructure with its associated amenities has paved a way to the private sector taking accountability for construction, management, finance and operations (Baer & Sirohi, 2015). The public sector, however, should maintain its dominant duty, for example analysing the infrastructure project's needs, supervising and monitoring the procurement system and ensuring all the safety and environmental standards in the provision of services are met and maintained.

The primary goal of PPP is to include the private sector in the delivery of public services, transferring the duties of the public sector to the guardian of the public interest. PPP is guided by that trust that the public sector will perform the duties and responsibilities given to it while the private sector is left to focus on its key functions effectively and efficiently. The major driver behind the PPP arrangement is to improve the infrastructure of the nation while supporting public services without putting too many constraints on the public funds that are often scarce while at the same time avoiding an increment on the amounts of taxes paid by the public (Fay, 1999).

The major advantages of PPP in the infrastructure construction projects involves removing the duty of financing the venture from the government. It introduces competition, hence expected development and betterment of service provision; utilization of the expert capacity and experience of the private sector in the implementation of the infrastructure projects; restructuring the public sector by adopting the private sector cultures and finally improved efficiency (Freeman & Warner, 2001).

Construction project management involves planning, control and coordination of the project from initiation to the final stage on behalf of the client. When dealing with infrastructure, the main external client is usually the public sector. The evaluation and control of the contribution to the project and the evaluation of substitutes in the quest to satisfy the client's desires with the outcomes of the project are important features of project management (Baer & Sirohi, 2015). Involvement of the private sector in the infrastructure construction projects helps produce better quantity and quality in the projects. Efficiency among many other benefits are achieved by the involvement of the private sectors. Private infrastructure projects that do not recognize the risk shifted to them often deliver very few benefits to the project. These risks may involve the regulatory framework, engineering and competition for customers. Private sector involvement has brought positive effects. Private involvement in infrastructure development when combined with a good regulatory system will help improve the deliverables.

The field of infrastructure is widely developed in Brazil. This has come with several challenges that are facing construction-experienced companies in this country. Brazil's wide investment in infrastructure sheds some light on the infrastructure gap. Infrastructure construction projects often promote export competitiveness and internal integration (Klein & Roger, 1994). Huge investment in infrastructure in return enhances macro-economic growth. Brazil, however, cannot be termed as a country that has invested in infrastructure enough. It is a country with a very large purchasing power, huge responsibility in the global platform and a wide range of resources.

To conquer the gaps more effectively in the construction of infrastructure industry, the private sector has to be actively involved by investing and providing services to the projects. In Brazil its great potential in the global market is often delayed by lack of sufficient infrastructure which in turn away potential private investors. According to Amann and Barrientos (2014), rather than privatization of this sector, it

is best when the government and the private sector form partnership to aid development. The government will aid in regulatory processes while the private sector will provide some services and even funding. According a survey that had been carried out by the World Bank in 2007, it takes about 120 days to kick off a business project in Brazil while it should normally take only 45 days on average in other regions.

Public private partnerships in the Latin America's vary in a major way in different countries. This type of partnership has been proved very beneficial, has therefore gained huge acceptance in the construction of infrastructure from country to country, and has revealed certain drawbacks, but the advantages of the PPP model have proven valuable. Infrastructure demand in Brazil came to a rise in the period before the world cup and the summer Olympics. According to Foster and Tre (2000) in Brazil, Energy infrastructure leads to an estimated 36.6% with other sectors such as telecommunications are at (18.8%), followed by rail (15.9%), roads (13.3%), sanitation (10.7%) and ports (4.7%). The infrastructure in Brazil is generally viewed to be insufficient while measured by international standard. This often results in a huge gap in the potential to grow its economy. The main infrastructures where it lags behind includes airports, ports and roads.

The rest of the sectors that require investments include, sanitation and water, electricity, health care and telecommunication. Between 2006 and 2009, infrastructure investment in Brazil was at 2.1% of the gross domestic product (GDP). The private sector has been given a growing role and as a result, infrastructural investment has been accelerated across many sectors. This development arose with the trend of privatizations in the 1990s in the public utilities sector (Baer & Sirohi, 2015). This arrangement has continued, especially with the establishment of Public Private Partnerships. After independence in the 19th century, Brazil embraced strategies openness to foreign direct investment Infrastructure and trade in its Part in Brazil's process of development (Amann & Barrientos, 2014).

3.4 Definition of Failure and Success in Projects

While Pinto & Mantel (1990) understand that it is arduous to define exactly what is an unsuccessful project, the PMBOK⁵ (Project Management Institute, 2004) reveals that the failure or the success of a specific project can be measured by the contrast

⁵ Project Management Body of Knowledge

between what is expected from the project during and after its conclusion and the real performance of this project. In brief, when the expectations of the project owner and other stakeholders regarding the time, costs and scope are not matched the project is considered as a failure project.

Frese (2003) defines a successful project as a project that is finished on time, on budget and with the operation factors as defined initially. On the other hand, the project challenged are those that were finished, however, they utilized excess expenses, excess time and all the factors and operations that were initially defined were not attained. On the contrary, failed projects are those that were abandoned or called at some in the life cycle of the project and hence the shareholders encountered complete loss. The Standish Group (2013) in its annual report that presents the failure and success statistics in IT projects also adopts this definition.

For Merrow (2011) success is described as the lack of failure and the conditions to classify a project, as a failure is very well defined and measurable. Megaprojects, here defined as projects with CapEx⁶ higher than USD 1 billion, are considered as a failure if:

Threshold for Failure	
Type of Outcome	Threshold for failure
Cost overruns (1)	>25%
Cost competitiveness (2)	>25%
Slip in execution schedule (3)	>25%
Schedule competitiveness (4)	>50%
Actual production versus planned	Significant reduced production into year 2

(1) Cost overruns are measured as the ratio of the actual final project costs compared with the estimation in the moment of full funds authorization.

(2) Competitiveness measured how much the project spent relative to other projects with similar scope.

(3) Slip in the execution schedule is defined as the actual schedule divided by the schedule forecast at full funds authorization.

(4) Schedule competitiveness is the length of execution relative to similar projects in the market.

Figure 6 – Threshold for Failure (Merrow, 2011)

⁶ Capital Expenditure, or CapEx, is the total amount invested in an asset.

Merrow understands that if one outcome described in the Figure 6 happen in a project is sufficient to heavily reduce or turn the project's NPV⁷ into negative or even substantially reduce the Internal Rate of Return that was promised to the investor.

Merrow also realized that in the world of normal sized projects, when projects are analysed regarding to how well they turn out to be, there is a big group of mediocre projects in the middle, a smaller group of good projects and a slightly larger group of poor projects. On the other hands, big projects are more common to fall mainly into two groups: Exceptionally good projects and exceptionally poor projects with only few in the middle. This is the reason of why Merrow separated the megaprojects into success or failure without any other group in the middle.

Sutton (2005), as Frese (2003), was focused on IT projects and believes that projects are not dichotomous regarding to success and failure but there are levels of success. A model has been defined to classify the projects regarding to its success. This model consists into four levels: Project Management Success; Repeatable project management success; Project Success; and Corporate Success.

Sutton proposes that there is a clear distinction between the four success levels in his model. The Sutton's project success model considers if a project has produced the planned deliverables, equally important, considers if a project has achieved its objectives. In brief, for Sutton, project deliverables and objectives are distinct. Constant and repetitive project management success refers to the company's ability to repetitively executing projects that have delivered the desired outputs. Corporate success, on the other hand, is about to whether the outcomes produced have an impact on the company's business strategy. Sutton's (2005b) project success model is shown in the Figure 7 that illustrates the model concepts by showing the relationship between the success levels and the respective project affect.

⁷ Net Present Value, or NPV, of a project is the difference between the present value of cash inflows and the present value of cash outflows of the project.

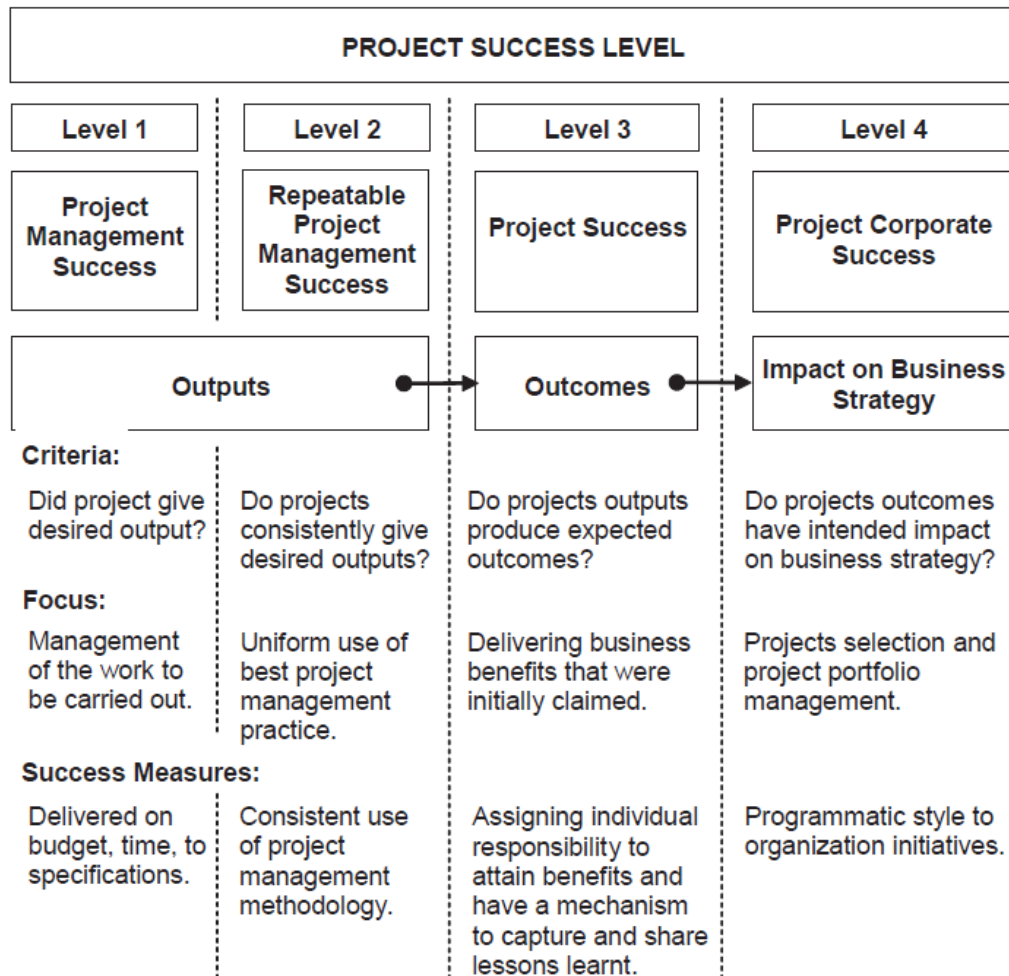


Figure 7 – Project Success Framework according Sutton (2005) (Camilleri, 2011)

A long research done by Camilleri (2011) among the literature offering success and failure causes for projects, shows that some specific factors that contributes both to the success and failure of projects are more frequently cited than others. Based on that, Camilleri defined that the most important factors to ensuring the project success are the following:

- Project Planning and Control
- Project Strategy Fit
- Project Scope
- Employee Commitment and Participation

The Table 1 shows Camilleri’s literature research outcomes with the factors classified from the most important, or most cited, to the least important, or the least factors cited by literature.

Factors	Failure	Success	Total	%
Project Planning and Control	26	58	84	23.60
Project Strategic Fit	13	35	48	13.48
Project Scope	19	24	43	12.08
Commitment and Participation	7	32	39	10.96
Communication	10	21	31	8.71
Management and Leadership	8	19	27	7.58
Project Risk Management	10	15	25	7.02
Project Organization Structure	4	16	20	5.62
Information Flow and Knowledge Management	3	15	18	5.06
Project Team Structure	4	13	17	4.78
Project Competency Development	0	4	4	1.12
Total:	104	252	356	100.00

Table 1 – Main Success and Failure Factors in Projects (Camilleri, 2011)

According to Kerzner (2013), to define success and failure is not a clear cut since there is a grey zone between a complete failure to a complete success.

Kerzner also seeks the support of the triple constraint idea to define project success and failure. The triple constraint, also known as the project triangle or the iron triangle, is the combination of the most important and significant restrictions faced in a project, which are scope, time and cost. It is fair to say that the agreed scope, time and cost when the project is kicked-off are definitely the most important outcomes of a project.

Project success, according to the triple constraint can be stated as completing the project within the agreed time, cost and scope and project failure the inability to meet the requirements within time, cost and scope.

When the Project Management Institute released the fourth edition of the PMBOK the original term triple constraints was replaced by the term “competing constraints” adding quality, resources and risk as part of the dimensions that compete for project resources and a change in one of these dimensions, will certainly impact the others. Figure 8 shows below graphically these concepts.

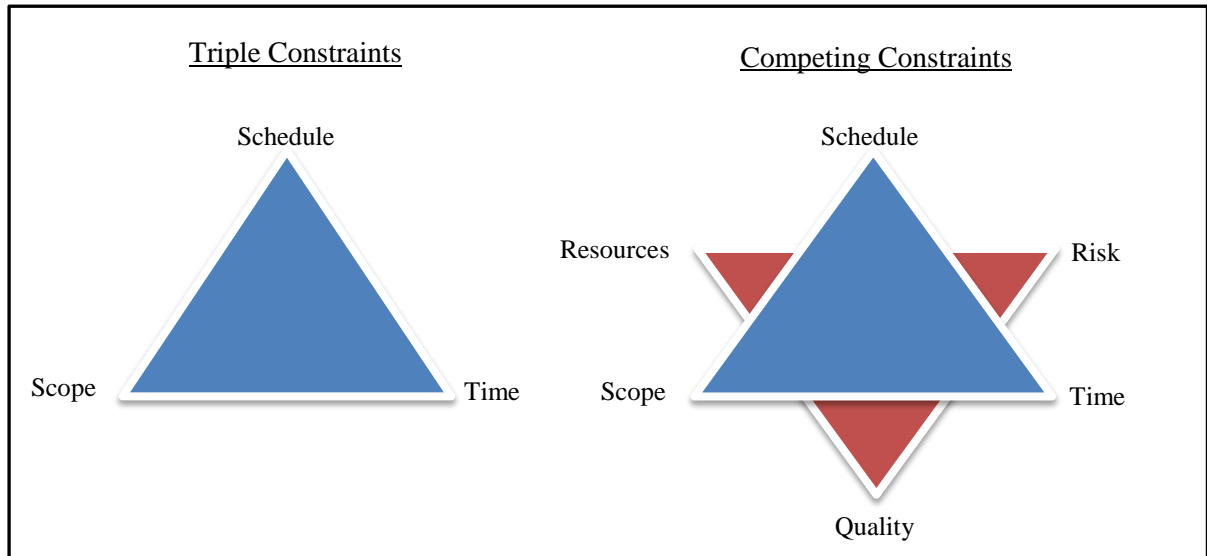


Figure 8 – Triple Constraints and Competing Constraints

Goldratt & Cox (1992) concluded that the goal of a company is the ultimate reason why a company exists. Every activity in a company is geared towards achieving the goal. The goal of all companies is to make money, which in the case of companies that are project oriented, can happen only with positive net present value for these projects.

Using the companies' goal from Goldratt & Cox (1992) to define a project success and failure, it is possible to state that successful projects are projects that are able to make money, or projects with a positive net present value, or an internal rate of return (IRR) greater than the weighted average cost of capital (WACC), and unsuccessful projects are the opposite, are projects with a negative net present value or $IRR < WACC$.

3.5 Failure in Infrastructure Construction Projects

The high rate of failures of infrastructure construction projects clarifies that the process of construction is not predictable and ordered, as it may appear (Othman & Ahmed, 2013 & Chitkara, 1998). Kerzner (2013) reports that most people have a relatively poor understanding of what is meant by project success and failure. The construction process is a nonlinear, dynamic and complex phenomenon that presents many challenges. It involves various processes and stages, including business development, engineering, bidding, permitting, pre-construction, construction and post-construction that need special skills, expertise and techniques to keep it on the

right track. The construction process is constantly changing with the development of advanced technologies. The complexity of the construction process is due to long duration taken to complete a construction project, the need to produce unique projects due to globalization, integration of different specialities, high uncertainty and risks involved (Nguyen & Chileshe, 2015). Therefore, infrastructure construction projects are richer in failures than successes. Construction of large assets involves many people, requirements, and activities achieve its goals. Furthermore, large construction projects are also complex because it is restricted to the budget, time and quality specification to satisfy the customer (internal and external). The failure of construction project causes great losses to the investors, shareholders, employees, creditors and stakeholders (Norman, 2012).

As mentioned, it is common to see infrastructure projects failing to achieve their mission of creating a facility with the given specifications, at the specified time and cost. Various factors can be associated with the failure of infrastructure construction project. These factors can be classified into four categories. First is the inadequate project development phase. It occurs when there is a poor field investigation and consequently inadequate project estimates and specifications. This problem leads to other problems during this phase, which is poor cost estimates, poor planning, inadequate project analyses and poor investment decision. During the development phase, which is prior to the contractor mobilization, the project owner representatives set the investors' expectations regarding the project performance in order to get the approval from the investor do move the project ahead. These goals and expectations, set during the development phase, will haunt the management team for the rest of the project lifetime and if these expectations are defined based on poor information, the project tends to fail miserably. Second is the lack of financial capacity. It is also associated with the inadequate scope; cost and time plan during the development phase, but could also happen that the investor has only part of the financial resources to execute the project and depends on new partners to join before the project completion. The third category of factors that causes construction failure is the lack of proper contract planning and management. It occurs due to poor post award contract management and improper pre-contract action. The last category is the poor project management. Project management in construction refers to the application of skills, techniques, knowledge and tools to carry out activities to meet the objectives of the project (Chitkara, 1998 & Nguyen & Chileshe, 2015). Ineffective and inefficient working delays, changes in the

location and scope of work cause project failures. In the management of the construction project, the objectives should be identified and the needs, concern and expectation of the customer should be met. Poor project management leads to the wrong actions causing failures. Inability to evaluate the situation and balance the demands of the stakeholder introduces risks. Moreover, lack of proper project management causes failure due to inability to manage the project to a higher level of accuracy as it develops. However, reasons for construction project failure are endless. Failure can also be due to unforeseen natural calamities such as earthquakes, natural disasters, and floods. It can also result from the deliberate attempt made by the manipulator by incorporating inaccurate cost and time estimates to start a project or secure business. These inaccuracies can lead to unrealistic objectives and thus create a problem during the implementation stage. However, the main cause of failures can be attributed to management failure and cost estimation failure (Divakar & Subramanian, 2009).

Cost estimation failure occurs due to failure to achieve project expectation and requirement. Cost estimation during construction is a continuous process that calls for financial commitment at various levels by different people involved in the project (Othman & Ahmed, 2013). The estimation of cost presents many challenges. Different methods can be applied to estimating project cost and the method used should be based unit cost of the facility that in turn depends on many factors such as location resources availability and specifications. Cost estimation failure can arise due to poor project specifications, poor planning, poor communication, design errors, poor risk management and construction deficiencies (Chitkara, 1998 & Norman, 2012).

The success of construction projects remains an uphill task. Belassi & Tukel (1996) contend that achieving success in construction projects is difficult because the process requires efficiency, quality, proper management, proper planning and appropriate communication. In the context of infrastructure construction projects, failure refers to the inability of a project to satisfy the stated specification, cost and time. A construction project is considered to have failed if the occurrence of the budget overrun, completion time exceeds the due date and when its outcomes do not fulfil the expectation of the customer or performance criteria. Pinto & Slevin (1997) asserts that a successful project must be completed by the deadline, meet the budget, fulfil the planned objectives and meet stakeholders' expectations. According to Divakar & Subramanian (2009) four factors that are associated with construction project success: pre-project planning and clarity with the scope, awareness, and compliance with the

rules, monitoring and efficient collaboration with the project participants. Therefore, failure of construction projects is the opposite of success. Although it is not possible to ensure a high level of construction project success, if the capabilities to exclude factors that cause failure still exists (Camilleri, 2011 & Belassi & Tukul, 1996).

The rate of construction project failure is increasing worldwide. The expertise shortage remains a challenge in the construction industry. According to Gilge et al., (2015) construction industry continues to experience project failure in both developing and developed countries. However, developing countries have a higher rate of construction project failure than developed countries. Unlike developed, developing countries experience a shortage of technical skills, managerial capabilities, high design knowledge and competent human resource. One of the major challenges towards achieving the project objective is the lack of expertise needed. The failure of construction of a FIFA World Cup stadium in South Africa explains the impact of lack of skilled labour and expertise. Another challenge that has been associated with failure of construction projects worldwide is the lack of political support. Some of the projects that have failed due to lack of support from the government include Saudi Arabia-Egypt Bridge, the Bandra-Worli Sea Link project and Western Desert New Axis Project. From the beginning of 2011 to the end of 2013, only 31% of the construction projects meet the estimated budget. During the same period, only 255 of the construction projects met the deadline. The majority of the project owners associated the project underperformance with the poor contractor performance. In 2014, Europe accounted for the highest number successful construction projects in the airport sector followed by Asia Pacific, North America, Latin America, Africa and the Middle East (Othman & Ahmed, 2013).

In 2012-2014, Brazil was among some countries that recorded the highest failure to complete construction projects (Berssaneti & Carvalho, 2015). One of the Brazilian shortcomings in the construction industry is the lack of planning. The country faces disappointments due to failure to complete mega projects in time. Projects such as a bullet train to connect Rio de Janeiro, Sao Paulo, and Campinas, subways in Salvador and Curitiba were cut short due to lack of poor planning and absence of strategies. Lack of planning has caused failure of construction projects in Brazil due to poor cost estimation and lack of clear project objectives. The rate of failure in construction in Brazil was highest in World Cup construction projects and airport construction projects. In 2014, the majority of the cities that held World Cup projects started the projects in

April and expected to finish them by May the same year. Due to the tight schedule, and the need for the project to be ready in time for the event there was no time for tests and adjustment that would be required. In Airport sectors, the situation is critical despite the launching of a strategic plan to manage construction projects in this sector (Othman & Ahmed, 2013). Therefore, the leading cause of construction project failure in Brazil is poor planning due to lack of adequate time.

Merrow (2011) reported on his research that in a sample of 318 global Megaprojects, 65% fail, according to Merrow's thresholds for failure showed in the Figure 6. These projects were spread in several sectors such as Oil and Gas, Pipelines, Power generation, Minerals and metals, logistics and others.

3.6 Summary of the Key Points

Infrastructure construction projects are projects dedicated to building the basic facilities needed for the operation of the society. These facilities can be divided into five big categories, which are logistics and transportation, power, telecommunications, hydraulic, urban buildings and other systems.

Investments in infrastructure projects are directly correlated with the country's wealth and can be done by governments or private companies through public private partnership contracts where the private partner has the rights to develop, build and operate the facility for a certain period of time. This type of instrument became recently very common in the Brazilian infrastructure market, especially in the power and logistics sectors that present a big gap when compared the actual development status and the real country needs.

Construction projects have many players, or stakeholders, as defined by the Project Management Institute (2013). These players are divided into two layers with the first layer being the project owner (investor), the contractor and the designer. In the second layer it is possible to find three different groups, the subcontractor group with material suppliers, equipment suppliers and service suppliers, the supervisory group with building code officials, labour unions and insurance companies and the permitting group with the federal government, local government banks and trade organizations.

Apparently, the construction projects are a predictable and ordered phenomenon that can be easily managed and coordinated. However, the high rate of failures of infrastructure construction projects defines that the construction process is not predictable and ordered, as it may appear (Othman & Ahmed, 2013 & Chitkara, 1998).

The triple constraint in project management refers to the three most significant restrictions of a project, which are scope, time and cost. These dimensions are present in most of the project success and project fail definitions in the literature since they are highly connected with the project feasibility and the project owner needs.

Merrow (2011) found 65% of failure rate in megaprojects, projects with CapEx higher than USD 1 billion dollars. In order to be considered as a fail, these projects had to attend at least one of the following five threshold for failure already described in the Figure 6:

- 1) Cost overruns: >25%
- 2) Cost competitiveness: >25% (*compared with similar projects*)
- 3) Slip in execution schedule: >25%
- 4) Schedule competitiveness: >50% (*compared with similar projects*)
- 5) Actual production vs planned: Significant reduced production into year 2

According to a database of 318 global megaprojects, Merrow found out that if a project presents one of the above conditions, the business case and the feasibility conditions of this project is lost and the project will present a negative net present value or the internal rate of return will be lower than the weighted average cost of capital.

According to Goldratt & Cox (1992), the ultimate goal of a company is to make money and this is the reason why it exists. In an event where a specific project delivers negative or near zero net present value to the company shareholders, the project is certainly considered as a fail. On the other hand, if a project manages to deliver a positive net present value, this project is generally considered as a success even if the net present value expected were bigger.

Despite of a large number of literature available about failure in projects, it was not found a research that measured the failure rate of infrastructure construction projects in Brazil, neither its root causes. Nevertheless, the failure and success factors catalogued by Camilleri (2011) and presented in the Table 1 are universal and were used as the starting point for the determination of the prospective root causes of failure of infrastructure construction projects in Brazil that will be researched in this dissertation.

Chapter 4. COLLECTION OF PRIMARY DATA

4.1 Methodology

As discussed in the Chapter 3, the literature review, sizeable construction projects have been failing globally at an impressive 65% rate (Merrow, 2011). The important factors that are causing these failures, as presented by Camilleri (2011) in the Table 1, have been affecting projects of all sizes and natures and shall be taken care of by project managers and sponsors.

Infrastructure construction projects in Brazil are definitely an important subject in the field of failure and success of projects, but no research has been found that measured specifically its failure rate and also the root causes of it.

In order to understand the failure rate of infrastructure construction projects in Brazil and the root causes of these failures a survey was designed to collect primary data. Part of the information collected during this survey will support the acceptance or rejection of the hypothesis presented in the chapter 2.3.

The survey is composed by a questionnaire with 5 pages and 12 questions in total and have collected quantitative and qualitative data among professionals with mandatory previous experience in infrastructure construction projects in Brazil.

The questionnaire was hosted by Survey Monkey ⁸website and the link to the survey was sent by e-mail to the targeted audience that is composed of 400 randomly selected engineering and construction professionals in a first phase and forwarded to several other professionals in a second phase. The statistical analysis was performed using the statistical tools available at the Microsoft Excel 2016 and the Real Statistics Resource Pack⁹.

4.2 Research Design

The research is based on questioning the targeted audience in different areas around the paper topics.

The research is designed to provide information about the profile of the respondents, their experience on the Merrow's (2011) threshold for failure, their opinion on how important are the causes derived from Camilleri's (2011) factors for

⁸ <https://www.surveymonkey.com/home/>

⁹ <http://www.real-statistics.com/free-download/real-statistics-resource-pack/>

success and failure of projects and an open estimate of infrastructure construction project failure rate with its root causes. The research is designed to be completed only by professionals with previous experience in infrastructure construction projects.

Regarding to the Merrow's (2011) five thresholds for failure, the cost competitiveness and schedule competitiveness being measurements that demand comparison of the project with similar projects in the market at the time of its development and/or execution will not be investigated during this research. The competitiveness' dimension is not contained to the project's internal reality and demand substantial knowledge of the project external environment what turns considerably difficult to receive reliable information from the respondents.

4.2.1 Type of Research

The executed research was a quantitative and qualitative research that aims to survey the targeted audience regarding to the aspects of failure in infrastructure construction projects in Brazil in order to confront the hypothesis stated in the chapter 2.3.

In the questionnaire made available to the targeted audience, was used alternative questions to understand the respondent profile, alternative questions to survey if the projects that the respondent participated reached the Merrow's threshold for failure and the Likert-type levels to understand the respondent's attitude regarding to the prospective root causes presented responsible for infrastructure construction project failure. The attitudes options in the research are the classical five levels: Strongly disagree; Disagree; Neutral; Agree; and Strongly agree. Points from 1 to strongly disagree to 5 for strongly agree will be given for each response in the analysis phase in order to draw up the conclusions and separate the main root causes for failure among the prospective ones.

The last part of the research contains two open questions in order to measure the understanding and opinion of the respondents regarding to the failure rate of infrastructure construction projects and the root causes of it. These open questions will allow the comparison of the failure rate found in the alternative questions regarding to Merrow's (2011) threshold for failure.

4.2.2 Design of the Research Instrument

The research's questionnaire, showed in the Appendix A (Portuguese) and Appendix B (English), was designed to be applied in Portuguese, since the targeted audience was composed mostly of Brazilian professionals acting in the Engineering and Construction sector. The questionnaire was divided into 12 questions in 5 pages with the initial page showing a brief explanatory text about the questionnaire, the paper purposes, a general explanation about the confidentiality of the individual responses and the author's contacts.

The questionnaire effectively starts on its second page that was designed specifically to collect information about the profile of the respondents regarding to their actual position in the company that they are working or the last company that they worked. This page also collects information about the respondents' professional and academic qualification, what type of company they most worked for (contractor, investor or designer/consultant) and about the years of experience in the Engineering and Construction sector. A summary of the questions and answer options of the page 2 of the questionnaire is shown in the Table 2 below.

Question Number	Text of the Question	Options Given
1	Do you have experience in Infrastructure Construction projects in Brazil ?	Yes No
2	What is your professional position ?	CEO, VP or Director Project Leader Project Manager Professional
3	What is your professional qualification ?	Engineer Architect Business Administration Technical Qualification Other
4	What is your academic qualification ?	Doctor Master Graduation Technical
5	How many years of experience in the Engineering and Construction sector?	0 to 3 years 3 to 5 years 5 to 10 years 10 to 20 years More than 20 years
6	What kind of company you most worked during your carrer?	Contractor Investor / Project Owner Designer or Consultant
7	How many infrastrucutre construction projects you have worked in Brazil?	1 2 3 4 5 6 7 8 9 10 or more

Table 2 – Questions 1 to 7 – Page 2 of the Research Questionnaire

Specifically, the question 1 of the second page is a qualification question and aims to understand if the respondent has previous experience in infrastructure construction projects or not. If not, the questionnaire presented a thank you message and the respondent was disqualified from the rest of the research. The information collected on the second page was used mainly for segmentation purposes.

Question 8, presented in the third page of the questionnaire, was designed to collect information from the construction infrastructure projects in Brazil that the respondent has knowledge or actively participated regarding the three thresholds for failure (Merrow, 2011) which are:

- 1) Cost overruns: >25% (Yes or No)
- 2) Slip in execution schedule: >25% (Yes or No)
- 3) Actual production vs planned: Significant reduced production into year 2 (Yes or No)

Enough space has been made available to the respondent insert information for ten infrastructure construction projects. For each project, besides of the threshold for failure, the respondent is also required to fill what is the type of the infrastructure project. The options available were:

- 1) Transport/Logistics
- 2) Power
- 3) Telecommunications
- 4) Hydraulic
- 5) Other Infrastructures

In order to reach the fourth page of the questionnaire, the respondent must fill at least the information regarding to one infrastructure construction project.

At the beginning of the fourth page of the questionnaire, the respondent faces on top of the page a clear explanation about what is considered an unsuccessful project. This was shown, in order to align the respondent with the failure definition adopted in this research since the next questions will require a clear understanding of this definition.

Question 9 was on the top of questionnaire's page 4 and inquired the opinion of the respondents regarding what phase most contribute to the infrastructure construction project failure in Brazil. The options given were the following

- 1) Business Definition Phase
- 2) Development Phase

- 3) Execution Phase
- 4) Operational Phase

In the question 10, that inquired about the root cause of failure of infrastructure construction projects in Brazil, the respondent had to give their opinion about the following statement: “The main Root Causes of Failure of infrastructure construction projects in Brazil are:”

The root cause options given to the respondents were:

- 1) Lack of project sponsor(s) support
- 2) Lack of proper scope definition
- 3) Lack of proper planning and control
- 4) Lack of project strategic fit
- 5) Lack of commitment of the project team
- 6) Inadequate / lack of communication
- 7) Improper management / leadership
- 8) Inadequate / lack of project risk management
- 9) Inadequate project organizational structure
- 10) Inexperienced project team
- 11) Lack of knowledge management
- 12) Failure in the cost estimation
- 13) Failure in the supplier/subcontractor management
- 14) Lack of payment
- 15) Acts of god / Force Majeure
- 16) No acceptance by the local communities
- 17) Uncontrolled environmental issues
- 18) Lack of supply management

For each root cause presented, items 1 to 18, the respondent had to classify it into five options of the Likert scale: “Strongly Disagree” (scores 1 point), “Disagree” (scores 2 points), Neutral (scores 3 points), “Agree” (scores 4 points) and “Strongly Agree” (scores 5 points).

From these root causes researched, the items 1 to 13, 17 and 18 are considered dependant variables, meaning that it is possible to control it. On the other hand, the items 14, 15 and 16 are considered independent variables, meaning that we cannot control them.

The questionnaire, since it was online, had a randomization option for the position of the presentation of these 18 causes to the respondent. This allows us to avoid any bias in the responses based on a tendency to give a high score in the first causes showed in the questionnaire.

The fifth and last page of the questionnaire had two open questions. In the first one, question 11, the respondent was asked to insert their opinion, between 0% and 100%, regarding to the failure rate of infrastructure construction projects in Brazil. The second and last question of the research, question 12, had 8000 characters available to the respondent to fill what are the main root cause(s) of the failure in infrastructure construction projects in Brazil in their opinion. The results of these last two questions will be used to compare the results find in the answers of the third and fourth page.

After the completion of the last page of the questionnaire, a thank you message was shown and the research was finished.

4.2.3 Sample Construction

In order to allow diversification into the researched population and accomplish the minimum required number of completed questionnaires, research was initially sent to 400 professionals of engineering and construction industry in Brazil with a mix of experiences, including contractors, professionals in the consultancy industry, designers, project owners, investors, etc. Besides the most significant professional experience, the mix was also in the professional seniority and actual position, being included in the population people working as field technicians, passing through project managers up to company CEOs and owners. The contacts were obtained in Engineering and Construction forums and in the author's contact list.

From the 400 professionals directly contacted and followed up additional two times, 55 questionnaires were completed. On the other hand, a bigger number of responses will be needed to allow the proposed segmentations in the primary research results. For this reason, nine senior key professionals in the market were contacted personally and asked to forward randomly the questionnaire to professionals of Engineering and Construction sector in Brazil that may have previous experience in infrastructure construction projects. In the end, 121 questionnaires were completed with information about 724 infrastructure projects, what is a representative random sample of the infrastructure construction projects in Brazil allowing the author to extend its conclusions to infrastructure construction projects in the Brazilian market.

Since the information collected in the questionnaire aims to understand technical and financial aspects of the infrastructure construction projects, only responses of professionals involved in this type of project were considered. For this reason, the first question of the questionnaire asks if the respondents have experience with infrastructure construction projects in Brazil. If this question was marked as “no”, the questionnaire redirects automatically the respondent to the thank you message and ends the research.

4.3 Research Execution

Before designing the online version of the questionnaire in Portuguese, the draft version of the questionnaire in English was sent to the mentor in a Microsoft Excel file in order to be reviewed and improved. This process of reviewing the questionnaire with the mentor helped to design each question with the appropriate options and proper linking it to the objectives of the paper. After reviewing the questionnaire according to the mentor’s guidance, the online version of the questionnaire was designed in Portuguese using the tools available on Survey Monkey website¹⁰. The author and mentor tested the online questionnaire and after that, the questionnaire was made available to the targeted audience through a web link.

The link to the questionnaire was sent by e-mail with an explanatory text about the objectives of the study. In this email, it was detailed the background of the researcher, the topics that will be addressed, the time needed to complete the questionnaire and also the confidentiality and anonymity of the individual responses.

There were other options to execute this research, such as sending a Microsoft Excel file by e-mail but this procedure would discourage some respondents. The reasons are many, as the time needed to open, respond, save it and send it back through e-mail, the issues with cyber security of this type of file, the lack of real guarantees of anonymity to the respondent and the lack of possibility to randomize the options in question 10 regarding to the root causes for failure and avoid a bias in the responses. An online questionnaire as designed also helped to disqualify the profiles that do not fit into the targeted audience with experience in infrastructure construction projects in Brazil avoiding them to spend unnecessary time to analyse, respond and send the questionnaire back.

¹⁰ www.surveymonkey.com

The questionnaire was opened to the public at May-30th, 2016 through the Survey Monkey website. It remained open for 20 days and was closed on June-18th, 2016. The online questionnaire achieved 135 respondents with an average time to respond of 8min and 27 seconds, which is close to the 10 minutes expected by the author.

4.4 Analysis of Data

4.4.1 Profile of Respondents

The questionnaire was sent to a group of 400 professionals and reached 60 responses in a first phase, which gives a return rate of 15% that can be considered as a normal rate of response for this type of online questionnaire. Later the questionnaire was forwarded to a larger number of professionals and reached a total of 135 responses.

From the 135 questionnaires responded, 121 were fully completed since they have responded “yes” to the question 1 (control question) that asked if the respondent had previous experience with infrastructure construction projects in Brazil. The results of the control question are shown in the Figure 9 and Table 3 next.

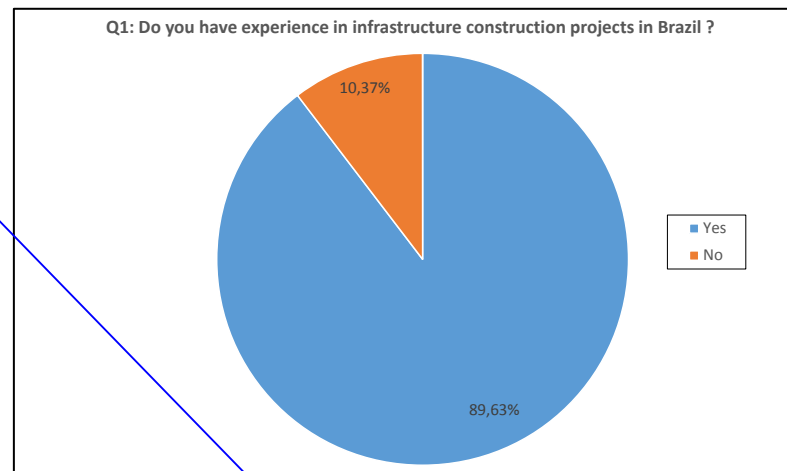


Figure 9 – Graph Question 1 – Experience in Infrastructure Construction Projects in Brazil

Do you have experience in infrastructure construction projects in Brazil ?		
Answer Options	Response Percent	Response Count
Yes	89,6%	121
No	10,4%	14
Total	100%	135
People that Answered the Question		135
People that Skipped the Question		0

Table 3 – Data Table Q1 – Experience in Infrastructure Construction Projects in Brazil

As a result of the responses obtained in the question 1, the total population that will be considered in this research is 121 respondents.

The distribution profile of the survey respondents segmented per position, academic level, years of experience in the sector and type of company is presented in the figures 10 to 14 and tables 4 to 8.

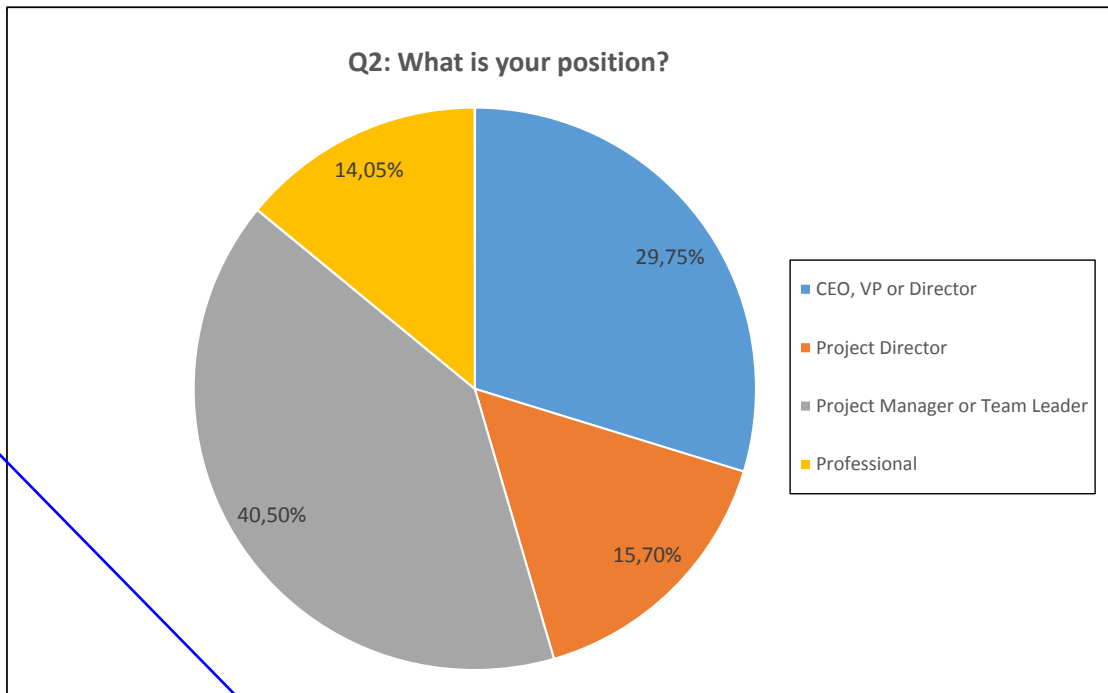


Figure 10 – Graph Question 2 – Segmentation by Position

What is your position?		
<i>Answer Options</i>	<i>Response Percent</i>	<i>Response Count</i>
CEO, VP or Director	29,8%	36
Project Director	15,7%	19
Project Manager or Team Leader	40,5%	49
Professional	14,0%	17
Total	100%	121
People that Answered the Question		121
People that Skipped the Question		0

Table 4 – Data Table Q2 – Segmentation by Position

Among the respondents to the question 2, the majority act as Project Manager or Team Leader with 40.5% and the second largest group are the senior/executive

leaders (CEOs, VPs and Directors) with 29.8%. Project Directors with 15.7% and Professionals with 14.0% are the less common positions occupied among the respondents.

In general, the professionals in charge of the strategic decisions of the company responded 1/3 of the questionnaires and 1/2 of the questionnaires was responded by the professionals in charge of a specific project or department.

Question 3 divided the respondents according to their professional qualification. The large majority of the respondents, 86%, are graduated as engineers as shown in the results below.

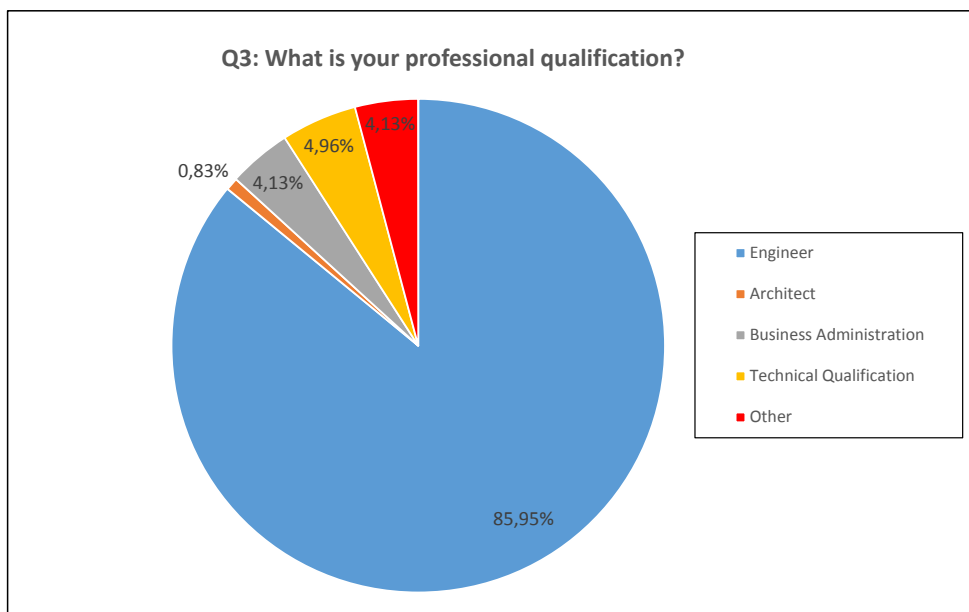


Figure 11 – Graph Question 3 – Segmentation by Professional Qualification

What is your professional qualification?		
<i>Answer Options</i>	<i>Response Percent</i>	<i>Response Count</i>
Engineer	86,0%	104
Architect	0,8%	1
Business Administration	4,1%	5
Technical Qualification	5,0%	6
Other	4,1%	5
Total	100%	121
People that Answered the Question		121
People that Skipped the Question		0

Table 5 – Data Table Q3 – Segmentation by Professional Qualification

The results of the question 3 only confirmed that the professionals that are dealing with infrastructure construction projects in the strategic and executive levels mainly graduate as engineers.

Question 4 inquired the respondents about their academic qualification. The majority of the responses were divided between graduation level and master level as shown in the Figure 12 and Table 6 below.

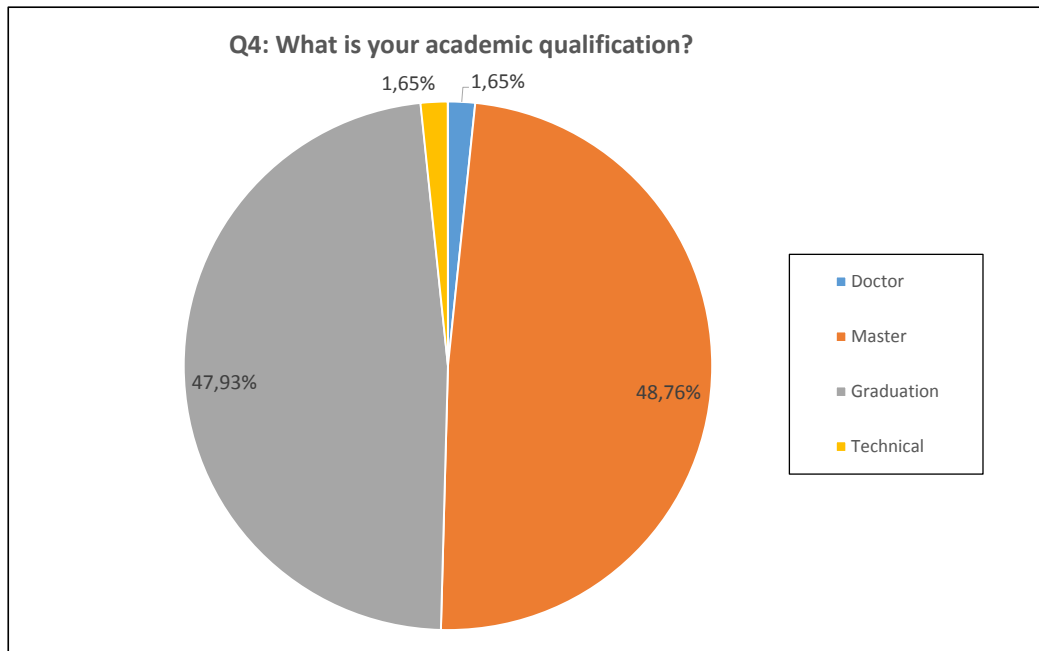


Figure 12 – Graph Question 4 – Segmentation by Academic Qualification

What is your academic qualification?		
<i>Answer Options</i>	<i>Response Percent</i>	<i>Response Count</i>
Doctor	1,7%	2
Master	48,8%	59
Graduation	47,9%	58
Technical	1,7%	2
Total	100%	121
People that Answered the Question		121
People that Skipped the Question		0

Table 6 – Data Table Q4 – Segmentation by Academic Qualification

Question 5 aims to understand the seniority of the respondents by enquiring about how many years of experience the respondent has. The majority have more than 20 years (60.3%). Only 1.65% of the respondent have less than 5 years of experience in the engineering and construction sector, which demonstrate that most of the

professionals researched, are senior professionals. The results are shown in the Figure 13 and Table 7 below.

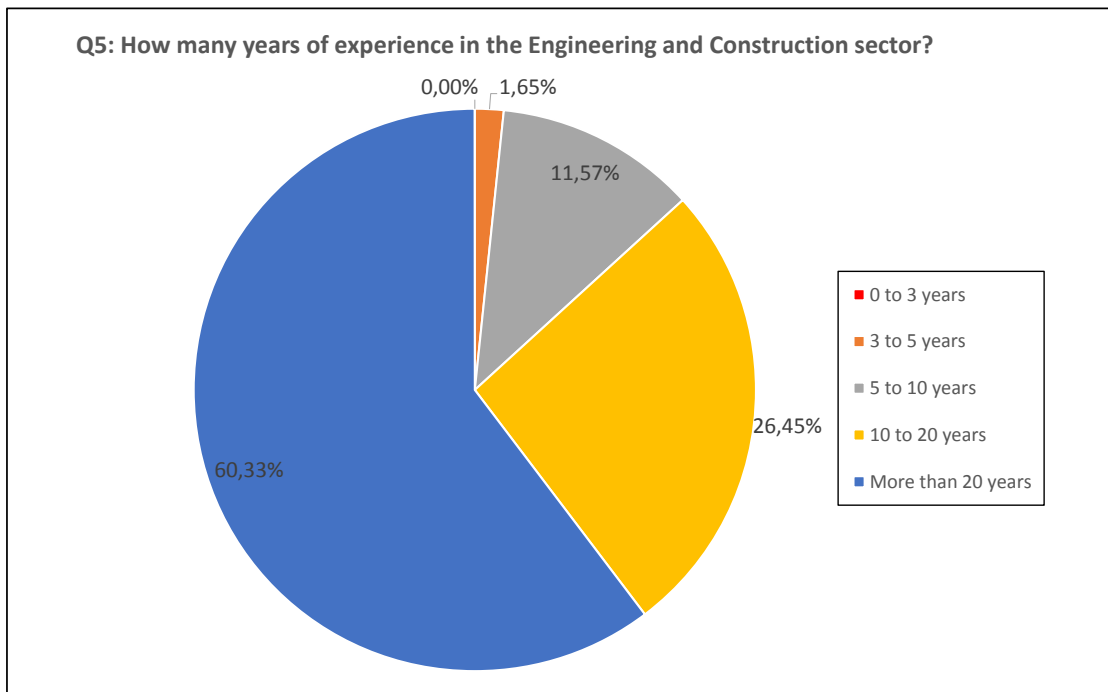


Figure 13 – Graph Question 5 – Segmentation by Years of Experience

How many years of experience in the Engineering and Construction sector?		
<i>Answer Options</i>	<i>Response Percent</i>	<i>Response Count</i>
0 to 3 years	0,0%	0
3 to 5 years	1,7%	2
5 to 10 years	11,6%	14
10 to 20 years	26,4%	32
More than 20 years	60,3%	73
Total	100%	121
People that Answered the Question		121
People that Skipped the Question		0

Table 7 – Data Table Q5 – Segmentation by Years of Experience

Question 6 split the respondents according to their most frequent type of employee. The options for this question are according to the primary layer presented in the Figure 5.

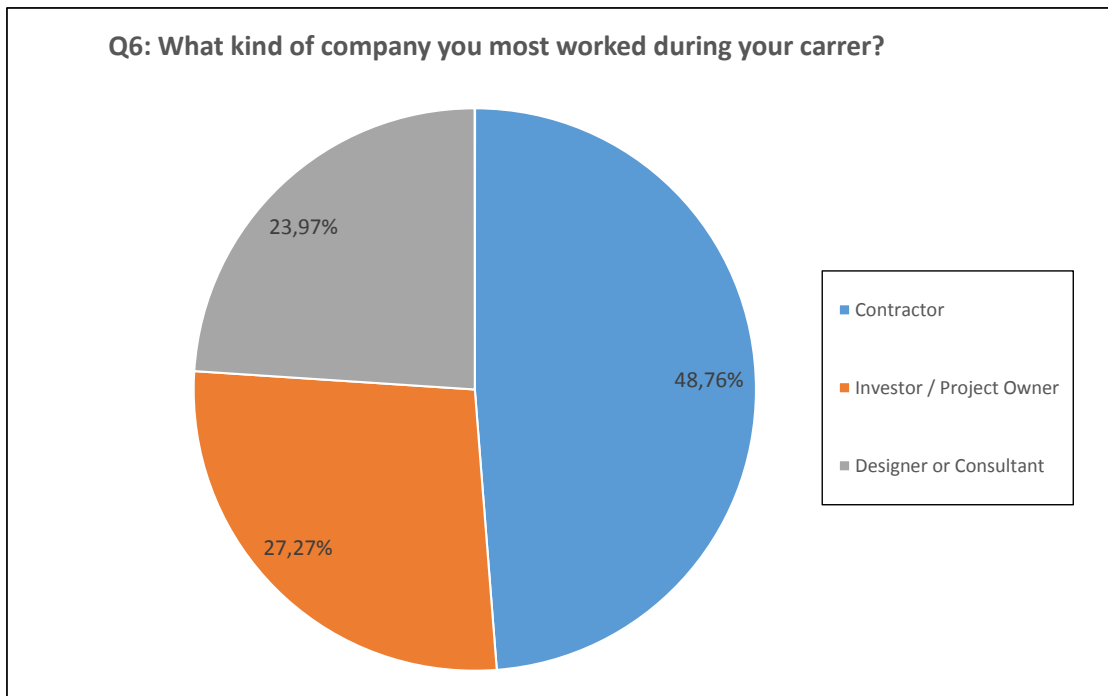


Figure 14 – Graph Question 6 – Segmentation Type of Company

What kind of company you most worked during your carrer?		
<i>Answer Options</i>	<i>Response Percent</i>	<i>Response Count</i>
Contractor	48,8%	59
Investor / Project Owner	27,3%	33
Designer or Consultant	24,0%	29
Total	100%	121
People that Answered the Question		121
People that Skipped the Question		0

Table 8 – Data Table Q6 – Segmentation Type of Company

The profile of the respondents regarding to the type of company that they most work during their career has balanced results. The majority of the respondents, 48.8% has the Contractor at his/her most significant experience. The remaining respondents came from the Project Owner / Investor (27.3%) and the Designer / Consultant (23.9%).

This equilibrium among the most significant experience of the respondents helps to guarantee a not biased characteristic in the research since they came from all different possible backgrounds.

4.4.2 Analysis of Responses

4.4.2.1 General Failure Rate

In its question 8, the primary research managed to collect valuable information about 724 infrastructure construction projects in Brazil regarding to three thresholds for failure as defined by Merrow (2011) and about the type of the project. Consequently, on average, each one of the 121 respondents provided information about approximately six infrastructure construction projects.

The incidence of each type of infrastructure construction project, using the infrastructure projects segmentation defined in the chapter 3.1 is presented in the Figure 14 and Table 9.

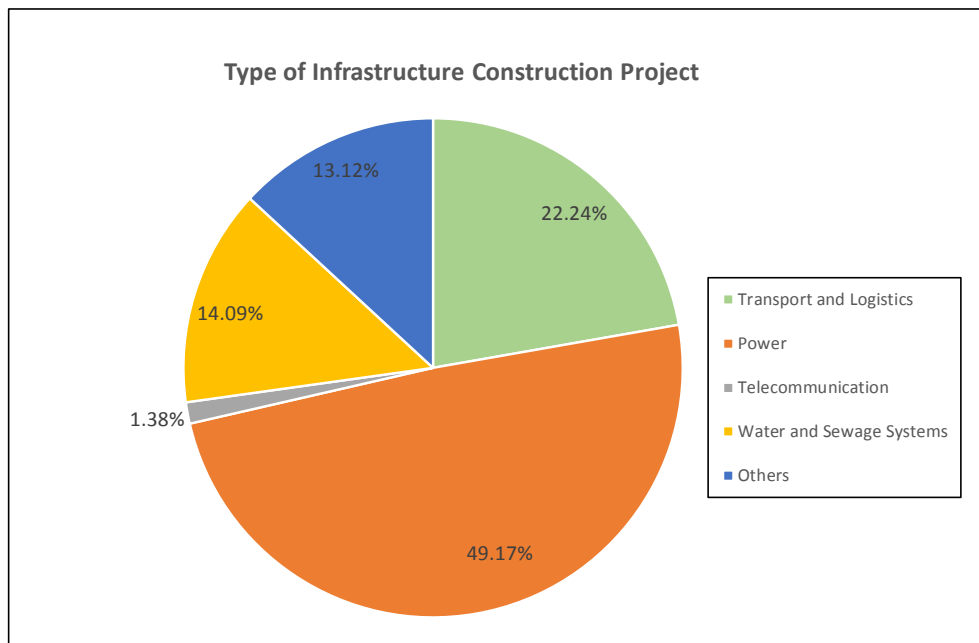


Figure 15 – Distribution of Type of Infrastructure Construction Projects

Type of Infrastructure Construction Project		
<i>Answer Options</i>	<i>Percentage</i>	<i>Number of Projects</i>
Transport and Logistics	22.2%	161
Power	49.2%	356
Telecommunication	1.4%	10
Water / Sewage Systemers	14.1%	102
Others	13.1%	95
Total	100%	724
People that Answered the Question		121
Average Project Number per Respondent		6.0

Table 9 – Type of Infrastructure Construction Projects

Based on the information of the 724 infrastructure construction projects collected in the question 8, it was possible to determine the general failure rate by interpreting the responses for each one of the projects and comparing these responses with the threshold for failure (Merrow, 2011). The three thresholds for failures analysed in this question were the following:

- Did this project have a cost overrun equal or greater than 25%? (Y/N)
- Did this project slip in execution schedule equal or greater than 25%? (Y/N)
- Did this project have a significant reduction in production into year 2? (Y/N)

Merrow (2011) stated that if a project marks positive in one of the three characteristics listed above, the project is considered as a failure since what has been promised to the investor cannot be achieved anymore. Based on Merrow’s (2011) definition, the general failure rate of infrastructure construction projects in Brazil is the following:

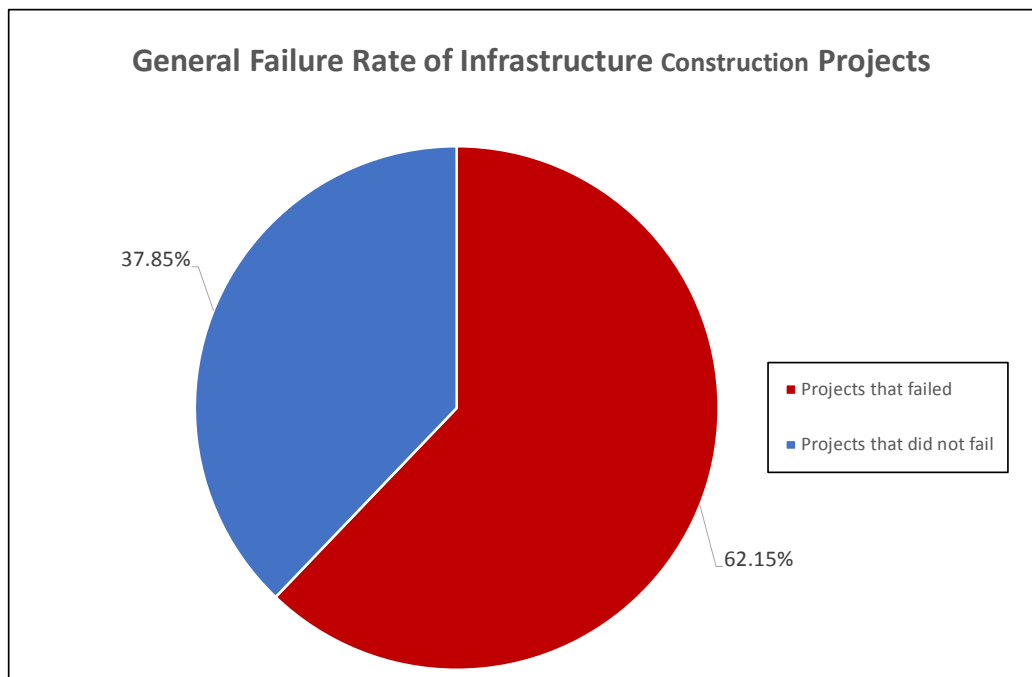


Figure 16 –Failure Rate of Infrastructure Construction Projects in Brazil

Failure Rate of Infrastructure Construction Project - Brazil		
Segmentation: NONE (All Projects / All Respondents)		
Options	Percentage	Number of Projects
Projects that failed	62.2%	450
Projects that did not fail	37.8%	274
Total Projects Sample	100%	724

Table 10 – Failure Rate Data of Infrastructure Construction Projects in Brazil

4.4.2.2 Failure Rate Segmentation

The responses to the question 8 (724 projects sample) can be segmented according to each one of the five types of infrastructure construction projects in Brazil, as described in the Table 9. The failure rate results when segmented per type of project is the following:

Failure Rate of Infrastructure Construction Project - Brazil		
Segmentation: Per type of infrastructure construction projects		
Segments	Failure Rate (%)	Projects Total Sample
Transport and Logistics	70.8%	161
Power	60.1%	356
Telecommunication	60.0%	10
Water and Sewage Systems	56.9%	102
Others Infrastructure Construction Projects	61.1%	95

Table 11 – Failure Rate Segmentation per Type of Infra Construction Project

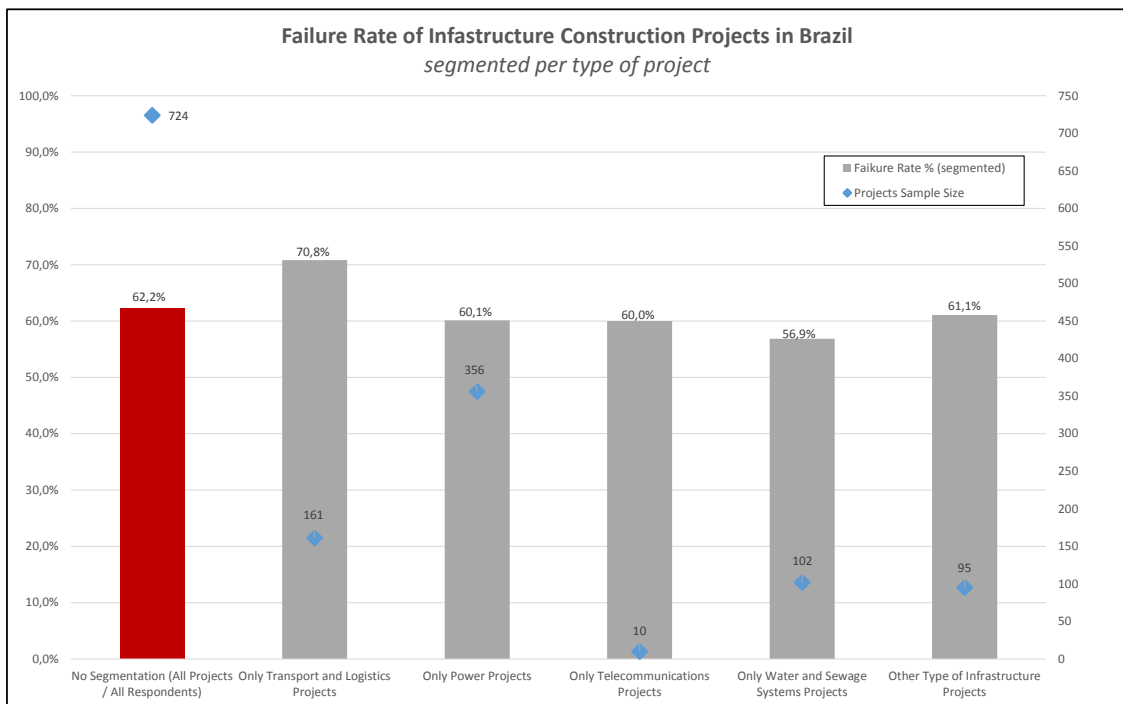


Figure 17 – Failure Rate Segmentation per Type of Infra Construction Project

Equally important, the responses to the question 8 can also be segmented per type of company that the respondent works or worked more frequently during his/her carrier. The “type of company” segments were defined according to the primary layer of Figure 5 that describes the general stakeholders of the construction projects.

The failure rate of infrastructure construction projects segmented per respondent's type of company is shown in the Table 12 and Figure 18 below:

Failure Rate of Infrastructure Construction Project - Brazil		
Segmentation: Per type of respondent's company		
Segments	Failure Rate (%)	Projects Total Sample
Contractor	70.8%	339
Project Owner / Investor	54.4%	206
Designer / Consultant	54.7%	179

Table 12 – Failure Rate Segmentation per Type of Respondent's Company

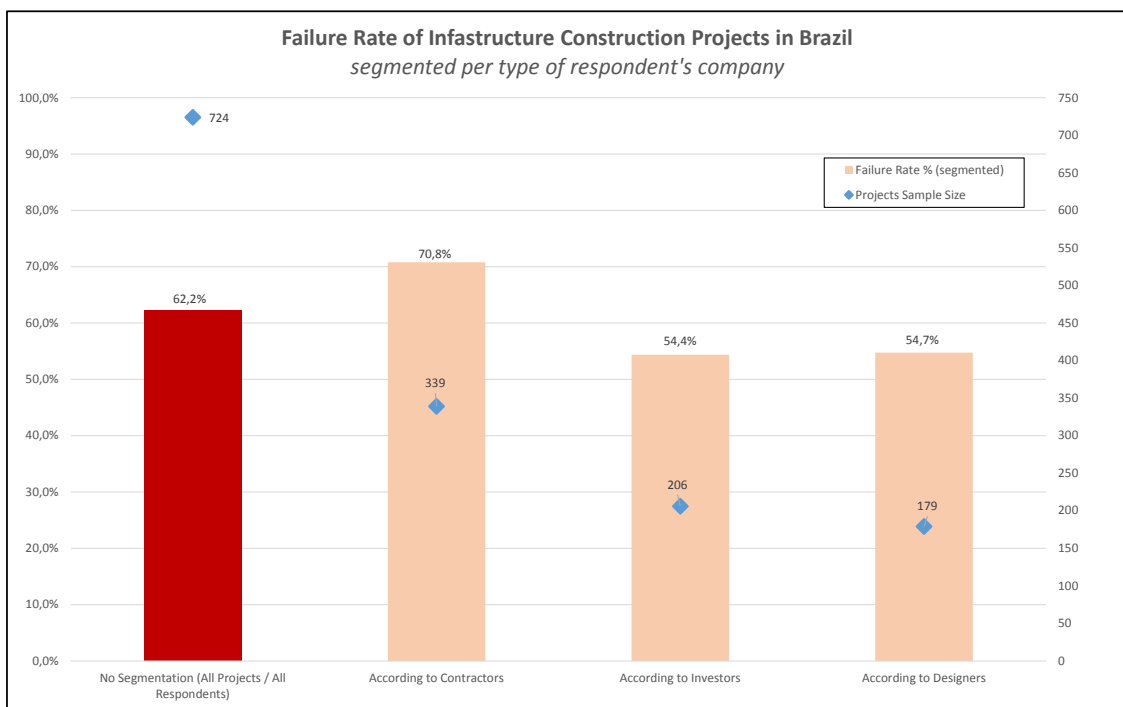


Figure 18 – Failure Rate Segmentation per Type of Respondent's Company

The failure rate can also be segmented by the respondent's position in the company, his/her years of experience and the respondent's academic qualification. The next tables show the results of these segmentations.

Failure Rate of Infrastructure Construction Project - Brazil		
Segmentation: Per respondent's professional position		
Segments	Failure Rate (%)	Projects Total Sample
CEO, VP or Director	64.8%	230
Project Director	60.5%	129
Project Manager or Team Leader	61.3%	261
Professional	60.6%	104

Table 13 – Failure Rate Segmentation per Respondent’s Professional Position

Failure Rate of Infrastructure Construction Project - Brazil		
Segmentation: Per respondent's academic qualification		
Segments	Failure Rate (%)	Projects Total Sample
Master Level	66.2%	382
Graduation Level	59.0%	322

The Doctor and Technician academic qualifications didn't reach the minimum sample of 6 respondents

Table 14 – Failure Rate Segmentation per Respondent’s Academic Qualification

Failure Rate of Infrastructure Construction Project - Brazil		
Segmentation: Per respondent's years of experience		
Segments	Failure Rate (%)	Projects Total Sample
5 to 10 years	61.3%	88
10 to 20 years	60.6%	178
More than 20 years	66.2%	454

The levels of 0 to 3 and 3 to 5 years of experience didn't reach the minimum sample of 6 respondents

Table 15 – Failure Rate Segmentation per Respondent’s Year of Experience

The segmentation per professional qualification, as information collected in the question 3 is not presented since 86% of the respondents are engineers and the other qualifications did not reach the minimum of six respondents to be considered as a significant segmentation. For illustration purposes, the failure rate found among this segment (engineers) was 61.2%, almost identical do the non-segmented case.

4.4.2.3 Failure Rate Critical Phase

Question 9 inquired respondents about the phase that most contribute to the failure in infrastructure construction projects in Brazil.

Four options were made available covering the entire life cycle of an infrastructure asset. The options for the question 9 were:

- Business Definition Phase
- Development phase
- Execution phase
- Operational phase

A total of 118 respondents answered questions 9, which is three respondents less than the 121 respondents for the questions 1 to 8. The results for the Question 9 is shown in the Figure 19 and Table 16 below:

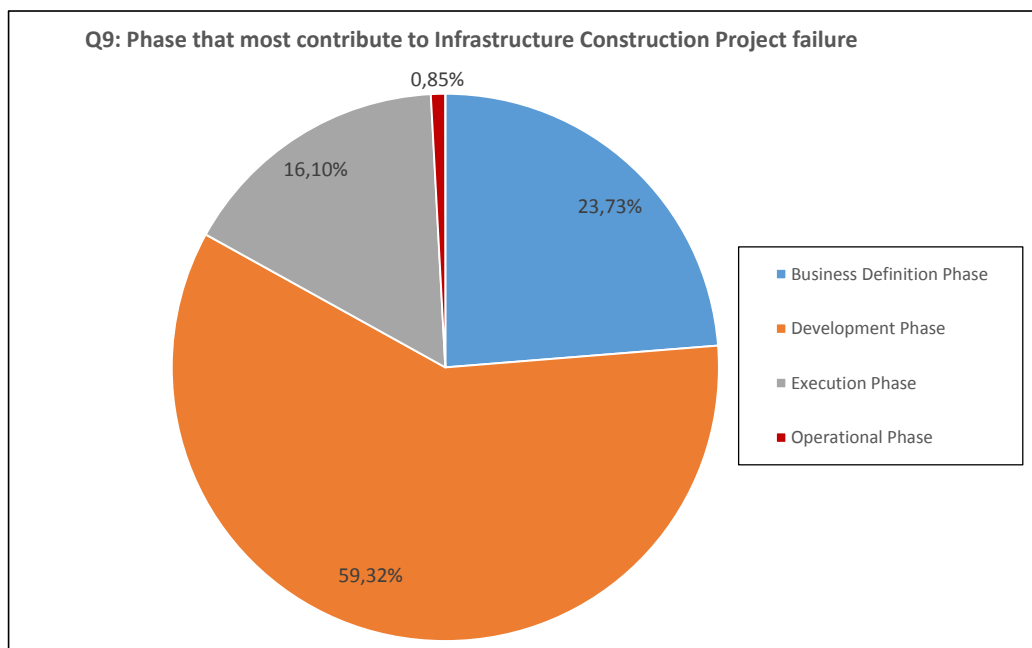


Figure 19 – Graph Question 9 - Phase that Most Contribute to Failure

The phase that most contribute to Infrastructure Construction Project failure is:		
<i>Answer Options</i>	<i>Response Percent</i>	<i>Response Count</i>
Business Definition Phase	23,7%	28
Development Phase	59,3%	70
Execution Phase	16,1%	19
Operational Phase	0,8%	1
Total	100%	118
People that Answered the Question		118
People that Skipped the Question		3

Table 16 – Data Table Q9 – Phase Most Contribute to Infra Construction Project Failure

4.4.2.4 Prospective Root Causes of Failure

Question 10 inquired 118 respondents about the Root Causes of Failure, allowing them to provide their perception in each one of the 18 causes presented derived from Camilleri's (2011) factors of failure and success in projects. The 18 prospective root causes researched are presented below:

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil
C1	Lack of project sponsor support
C2	Lack of proper scope definition
C3	Lack of proper planning and control
C4	Lack of project strategic fit
C5	Lack of commitment of the project team
C6	Inadequate / lack of communication
C7	Improper management / leadership
C8	Inadequate / lack of project risk management
C9	Inadequate project organizational structure
C10	Inexperienced project team
C11	Lack of knowledge management
C12	Acts of god
C13	No acceptance by the local communities
C14	Uncontrolled environmental issues
C15	Failure in the cost estimation
C16	Lack of payment
C17	Failure in the supplier/subcontractor management
C18	Lack of supply management

Table 17 – List of the 18 Prospective Root Causes of Failure Researched

The respondents had to classify each one of the 18 prospective root causes of failure, according to a five level Likert-type scale. The levels were the following:

- a. Strongly Disagree
- b. Disagree
- c. Neutral
- d. Agree
- e. Completely Agree

The results obtained based on the Question 8 responses are presented in the Table 18 and Table 19 below:

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	6	19	29	49	15	118
C2	Lack of proper scope definition	0	12	16	49	41	118
C3	Lack of proper planning and control	1	0	17	55	45	118
C4	Lack of project strategic fit	1	9	24	65	19	118
C5	Lack of commitment of the project team	6	33	26	40	13	118
C6	Inadequate / lack of communication	3	4	32	57	22	118
C7	Improper management / leadership	2	11	19	66	20	118
C8	Inadequate / lack of project risk management	1	6	21	63	27	118
C9	Inadequate project organizational structure	2	11	30	58	17	118
C10	Inexperienced project team	2	16	25	48	27	118
C11	Lack of knowledge management	5	11	30	53	19	118
C12	Acts of god	12	21	57	24	4	118
C13	No acceptance by the local communities	8	29	47	28	6	118
C14	Uncontrolled environmental issues	2	19	16	53	28	118
C15	Failure in the cost estimation	0	6	8	54	50	118
C16	Lack of payment	7	16	25	43	27	118
C17	Failure in the supplier/subcontractor management	4	7	34	55	18	118
C18	Lack of supply management	2	17	30	60	9	118
Totals		64	247	486	920	407	2124
		3.0%	11.6%	22.9%	43.3%	19.2%	100.0%

Table 18 – Prospective Root Causes of Failure – Total Responses per Likert Level

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Responses Distribution (%)					Total
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	5.1%	16.1%	24.6%	41.5%	12.7%	100%
C2	Lack of proper scope definition	0.0%	10.2%	13.6%	41.5%	34.7%	100%
C3	Lack of proper planning and control	0.8%	0.0%	14.4%	46.6%	38.1%	100%
C4	Lack of project strategic fit	0.8%	7.6%	20.3%	55.1%	16.1%	100%
C5	Lack of commitment of the project team	5.1%	28.0%	22.0%	33.9%	11.0%	100%
C6	Inadequate / lack of communication	2.5%	3.4%	27.1%	48.3%	18.6%	100%
C7	Improper management / leadership	1.7%	9.3%	16.1%	55.9%	16.9%	100%
C8	Inadequate / lack of project risk management	0.8%	5.1%	17.8%	53.4%	22.9%	100%
C9	Inadequate project organizational structure	1.7%	9.3%	25.4%	49.2%	14.4%	100%
C10	Inexperienced project team	1.7%	13.6%	21.2%	40.7%	22.9%	100%
C11	Lack of knowledge management	4.2%	9.3%	25.4%	44.9%	16.1%	100%
C12	Acts of god	10.2%	17.8%	48.3%	20.3%	3.4%	100%
C13	No acceptance by the local communities	6.8%	24.6%	39.8%	23.7%	5.1%	100%
C14	Uncontrolled environmental issues	1.7%	16.1%	13.6%	44.9%	23.7%	100%
C15	Failure in the cost estimation	0.0%	5.1%	6.8%	45.8%	42.4%	100%
C16	Lack of payment	5.9%	13.6%	21.2%	36.4%	22.9%	100%
C17	Failure in the supplier/subcontractor management	3.4%	5.9%	28.8%	46.6%	15.3%	100%
C18	Lack of supply management	1.7%	14.4%	25.4%	50.8%	7.6%	100%

Table 19 – Prospective Root Causes of Failure – Percentage of Responses per Likert Level

Table 20 presents the percentage of responses per Likert level with colour codes provided by the Microsoft Excel default setup that facilitate the observation of the most frequent responses for each prospective root cause.

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Responses Distribution (%)					Total
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	5.1%	16.1%	24.6%	41.5%	12.7%	100%
C2	Lack of proper scope definition	0.0%	10.2%	13.6%	41.5%	34.7%	100%
C3	Lack of proper planning and control	0.8%	0.0%	14.4%	46.6%	38.1%	100%
C4	Lack of project strategic fit	0.8%	7.6%	20.3%	55.1%	16.1%	100%
C5	Lack of commitment of the project team	5.1%	28.0%	22.0%	33.9%	11.0%	100%
C6	Inadequate / lack of communication	2.5%	3.4%	27.1%	48.3%	18.6%	100%
C7	Improper management / leadership	1.7%	9.3%	16.1%	55.9%	16.9%	100%
C8	Inadequate / lack of project risk management	0.8%	5.1%	17.8%	53.4%	22.9%	100%
C9	Inadequate project organizational structure	1.7%	9.3%	25.4%	49.2%	14.4%	100%
C10	Inexperienced project team	1.7%	13.6%	21.2%	40.7%	22.9%	100%
C11	Lack of knowledge management	4.2%	9.3%	25.4%	44.9%	16.1%	100%
C12	Acts of god	10.2%	17.8%	48.3%	20.3%	3.4%	100%
C13	No acceptance by the local communities	6.8%	24.6%	39.8%	23.7%	5.1%	100%
C14	Uncontrolled environmental issues	1.7%	16.1%	13.6%	44.9%	23.7%	100%
C15	Failure in the cost estimation	0.0%	5.1%	6.8%	45.8%	42.4%	100%
C16	Lack of payment	5.9%	13.6%	21.2%	36.4%	22.9%	100%
C17	Failure in the supplier/subcontractor management	3.4%	5.9%	28.8%	46.6%	15.3%	100%
C18	Lack of supply management	1.7%	14.4%	25.4%	50.8%	7.6%	100%
Colour Code Legend		0%	25%	50%	75%	100%	

Table 20 – Prospective Root Causes of Failure – Colour Coded Percentage

Table 21 presents the standard deviation and the measurements of central tendency such as arithmetic mean, mode and median for each prospective root cause. In order to perform this calculation, each Likert level was associated with a number of points as presented below:

- a. Strongly Disagree 1 point
- b. Disagree 2 points
- c. Neutral 3 points
- d. Agree 4 points
- e. Completely Agree 5 points

The results are the following:

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Sample Size	Total Likert Points	Median	Mode	Mean (μ)	Std dev (σ)
C1	Lack of project sponsor support	118	402	4.000	4.000	3.407	1.064
C2	Lack of proper scope definition	118	473	4.000	4.000	4.008	0.947
C3	Lack of proper planning and control	118	497	4.000	4.000	4.212	0.749
C4	Lack of project strategic fit	118	446	4.000	4.000	3.780	0.839
C5	Lack of commitment of the project team	118	375	3.000	4.000	3.178	1.114
C6	Inadequate / lack of communication	118	445	4.000	4.000	3.771	0.881
C7	Improper management / leadership	118	445	4.000	4.000	3.771	0.900
C8	Inadequate / lack of project risk management	118	463	4.000	4.000	3.924	0.829
C9	Inadequate project organizational structure	118	431	4.000	4.000	3.653	0.900
C10	Inexperienced project team	118	436	4.000	4.000	3.695	1.025
C11	Lack of knowledge management	118	424	4.000	4.000	3.593	1.006
C12	Acts of god	118	341	3.000	3.000	2.890	0.959
C13	No acceptance by the local communities	118	349	3.000	3.000	2.958	0.982
C14	Uncontrolled environmental issues	118	440	4.000	4.000	3.729	1.051
C15	Failure in the cost estimation	118	502	4.000	4.000	4.254	0.797
C16	Lack of payment	118	421	4.000	4.000	3.568	1.158
C17	Failure in the supplier/subcontractor management	118	430	4.000	4.000	3.644	0.929
C18	Lack of supply management	118	411	4.000	4.000	3.483	0.894
All Prospective Root Causes		2124	7731	4.000	4.000	3.640	1.014

Table 21 – Prospective Root Causes of Failure – Measurements of Central Tendency

4.4.2.5 Segmented Root Causes of Failure

The segmentation proposed for the root causes of failure are based on some characteristics in the respondent's profile in order to understand if different profiles have the same opinion of the root causes of failure of the infrastructure construction projects in Brazil.

The first segment of the Question 10 responses was made in the professional position level (Question 2 - Table 4 and Figure 9)

The results for the four different positions are shown in the Table 22, Table 23, Table 24 and Table 25 next.

Segmentation per Respondent's Professional Position - CEO, VP or Director							
Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	2	4	9	15	6	36
C2	Lack of proper scope definition	0	3	7	14	12	36
C3	Lack of proper planning and control	0	0	7	18	11	36
C4	Lack of project strategic fit	1	2	10	16	7	36
C5	Lack of commitment of the project team	0	8	10	16	2	36
C6	Inadequate / lack of communication	0	1	11	20	4	36
C7	Improper management / leadership	0	2	4	25	5	36
C8	Inadequate / lack of project risk management	1	2	6	18	9	36
C9	Inadequate project organizational structure	1	4	9	18	4	36
C10	Inexperienced project team	0	5	6	18	7	36
C11	Lack of knowledge management	2	3	9	15	7	36
C12	Acts of god	4	6	17	9	0	36
C13	No acceptance by the local communities	2	7	18	6	3	36
C14	Uncontrolled environmental issues	0	6	5	19	6	36
C15	Failure in the cost estimation	0	0	4	20	12	36
C16	Lack of payment	1	5	7	15	8	36
C17	Failure in the supplier/subcontractor management	2	2	7	20	5	36
C18	Lack of supply management	0	7	6	20	3	36
Totals		16	67	152	302	111	648
		2.5%	10.3%	23.5%	46.6%	17.1%	100.0%

Table 22 – Prospective Root Causes of Failure – Segmented by CEO, VP and Director

Segmentation per Respondent's Professional Position - Project Director							
Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	2	3	3	7	4	19
C2	Lack of proper scope definition	0	1	1	10	7	19
C3	Lack of proper planning and control	1	0	3	8	7	19
C4	Lack of project strategic fit	0	1	4	13	1	19
C5	Lack of commitment of the project team	1	7	3	6	2	19
C6	Inadequate / lack of communication	1	0	6	9	3	19
C7	Improper management / leadership	1	2	3	10	3	19
C8	Inadequate / lack of project risk management	0	1	4	11	3	19
C9	Inadequate project organizational structure	1	1	5	8	4	19
C10	Inexperienced project team	0	3	8	4	4	19
C11	Lack of knowledge management	2	2	4	10	1	19
C12	Acts of god	2	4	9	3	1	19
C13	No acceptance by the local communities	2	5	9	2	1	19
C14	Uncontrolled environmental issues	1	1	3	8	6	19
C15	Failure in the cost estimation	0	4	1	6	8	19
C16	Lack of payment	1	2	2	8	6	19
C17	Failure in the supplier/subcontractor management	1	0	8	9	1	19
C18	Lack of supply management	0	6	4	9	0	19
Totals		16	43	80	141	62	342
		4.7%	12.6%	23.4%	41.2%	18.1%	100.0%

Table 23 – Prospective Root Causes of Failure – Segmented by Project Director

Segmentation per Respondent's Professional Position - Project Manager or Team Leader							
Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	0	8	13	20	5	46
C2	Lack of proper scope definition	0	5	7	17	17	46
C3	Lack of proper planning and control	0	0	5	19	22	46
C4	Lack of project strategic fit	0	4	5	29	8	46
C5	Lack of commitment of the project team	4	10	10	14	8	46
C6	Inadequate / lack of communication	1	3	12	20	10	46
C7	Improper management / leadership	0	7	6	23	10	46
C8	Inadequate / lack of project risk management	0	3	8	24	11	46
C9	Inadequate project organizational structure	0	5	10	23	8	46
C10	Inexperienced project team	2	7	8	16	13	46
C11	Lack of knowledge management	1	5	12	19	9	46
C12	Acts of god	4	9	20	10	3	46
C13	No acceptance by the local communities	1	10	17	16	2	46
C14	Uncontrolled environmental issues	1	8	6	21	10	46
C15	Failure in the cost estimation	0	2	1	20	23	46
C16	Lack of payment	3	6	11	14	12	46
C17	Failure in the supplier/subcontractor management	0	4	14	18	10	46
C18	Lack of supply management	0	4	14	23	5	46
Totals		17	100	179	346	186	828
		2.1%	12.1%	21.6%	41.8%	22.5%	100.0%

Table 24 – Prospective Root Causes of Failure – Segmented by Project Manager

Segmentation per Respondent's Professional Position - Professional Level							
Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	2	4	4	7	0	17
C2	Lack of proper scope definition	0	3	1	8	5	17
C3	Lack of proper planning and control	0	0	2	10	5	17
C4	Lack of project strategic fit	0	2	5	7	3	17
C5	Lack of commitment of the project team	1	8	3	4	1	17
C6	Inadequate / lack of communication	1	0	3	8	5	17
C7	Improper management / leadership	1	0	6	8	2	17
C8	Inadequate / lack of project risk management	0	0	3	10	4	17
C9	Inadequate project organizational structure	0	1	6	9	1	17
C10	Inexperienced project team	0	1	3	10	3	17
C11	Lack of knowledge management	0	1	5	9	2	17
C12	Acts of god	2	2	11	2	0	17
C13	No acceptance by the local communities	3	7	3	4	0	17
C14	Uncontrolled environmental issues	0	4	2	5	6	17
C15	Failure in the cost estimation	0	0	2	8	7	17
C16	Lack of payment	2	3	5	6	1	17
C17	Failure in the supplier/subcontractor management	1	1	5	8	2	17
C18	Lack of supply management	2	0	6	8	1	17
Totals		15	37	75	131	48	306
		4.9%	12.1%	24.5%	42.8%	15.7%	100.0%

Table 25 – Prospective Root Causes of Failure – Segmented by Professionals

Second segmentation made in the Question 10 responses, and the one that will be statistically analysed, was regarding to the company that the respondent has its most significant professional experience (Question 6 – Figure 14 and Table 8)

The results for the four different positions are shown in the Table 26, Table 27 and Table 28 next.

Segmentation per Respondent's Company - Contractor							
Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	4	8	16	22	8	58
C2	Lack of proper scope definition	0	5	6	25	22	58
C3	Lack of proper planning and control	1	0	7	24	26	58
C4	Lack of project strategic fit	0	5	8	33	12	58
C5	Lack of commitment of the project team	4	17	15	16	6	58
C6	Inadequate / lack of communication	2	2	14	33	7	58
C7	Improper management / leadership	2	5	9	35	7	58
C8	Inadequate / lack of project risk management	0	4	11	32	11	58
C9	Inadequate project organizational structure	1	7	12	30	8	58
C10	Inexperienced project team	1	9	11	21	16	58
C11	Lack of knowledge management	2	5	11	29	11	58
C12	Acts of god	6	11	25	13	3	58
C13	No acceptance by the local communities	6	13	20	15	4	58
C14	Uncontrolled environmental issues	1	5	9	28	15	58
C15	Failure in the cost estimation	0	2	4	18	34	58
C16	Lack of payment	4	8	11	16	19	58
C17	Failure in the supplier/subcontractor management	3	6	16	24	9	58
C18	Lack of supply management	2	8	11	32	5	58
Totals		39	120	216	446	223	1044
		3.7%	11.5%	20.7%	42.7%	21.4%	100.0%

Table 26 – Prospective Root Causes of Failure – Segmented by Contractors

Segmentation per Respondent's Company - Project Owner / Investor							
Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	0	8	7	11	5	31
C2	Lack of proper scope definition	0	5	5	15	6	31
C3	Lack of proper planning and control	0	0	8	13	10	31
C4	Lack of project strategic fit	1	2	7	17	4	31
C5	Lack of commitment of the project team	1	10	5	11	4	31
C6	Inadequate / lack of communication	0	2	10	14	5	31
C7	Improper management / leadership	0	6	6	13	6	31
C8	Inadequate / lack of project risk management	0	2	7	13	9	31
C9	Inadequate project organizational structure	1	2	10	14	4	31
C10	Inexperienced project team	1	5	9	10	6	31
C11	Lack of knowledge management	2	3	14	8	4	31
C12	Acts of god	1	7	18	4	1	31
C13	No acceptance by the local communities	1	9	13	6	2	31
C14	Uncontrolled environmental issues	0	8	2	13	8	31
C15	Failure in the cost estimation	0	2	1	18	10	31
C16	Lack of payment	2	5	8	11	5	31
C17	Failure in the supplier/subcontractor management	0	1	10	15	5	31
C18	Lack of supply management	0	7	11	11	2	31
Totals		10	84	151	217	96	558
		1.8%	15.1%	27.1%	38.9%	17.2%	100.0%

Table 27 – Prospective Root Causes of Failure – Segmented by Investor / Project Owner

Segmentation per Respondent's Company - Designer / Consultant							
Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Responses per Likert Level					Sample Size
		Strogly Disagree	Disagree	Neutral	Agree	Strongly Agree	
C1	Lack of project sponsor support	2	3	6	16	2	29
C2	Lack of proper scope definition	0	2	5	9	13	29
C3	Lack of proper planning and control	0	0	2	18	9	29
C4	Lack of project strategic fit	0	2	9	15	3	29
C5	Lack of commitment of the project team	1	6	6	13	3	29
C6	Inadequate / lack of communication	1	0	8	10	10	29
C7	Improper management / leadership	0	0	4	18	7	29
C8	Inadequate / lack of project risk management	1	0	3	18	7	29
C9	Inadequate project organizational structure	0	2	8	14	5	29
C10	Inexperienced project team	0	2	5	17	5	29
C11	Lack of knowledge management	1	3	5	16	4	29
C12	Acts of god	5	3	14	7	0	29
C13	No acceptance by the local communities	1	7	14	7	0	29
C14	Uncontrolled environmental issues	1	6	5	12	5	29
C15	Failure in the cost estimation	0	2	3	18	6	29
C16	Lack of payment	1	3	6	16	3	29
C17	Failure in the supplier/subcontractor management	1	0	8	16	4	29
C18	Lack of supply management	0	2	8	17	2	29
Totals		15	43	119	257	88	522
		2.9%	8.2%	22.8%	49.2%	16.9%	100.0%

Table 28 – Prospective Root Causes of Failure – Segmented by Designer / Consultant

It is possible also to calculate the arithmetic mean of the root causes in the segmented options. A comparison between the mean values of the root cause for failure without segmentation and the segmented are presented in the tables below.

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Mean Values (μ)							
		Not Segmented	Segmented per Company			Segmented per Professional Position			
			Contractor	Investor	Designer / Consultant	CEOs, VPs, Directors	Project Director	Project Manager	Professional
C1	Lack of project sponsor support	3.407	3.379	3.419	3.448	3.528	3.421	3.478	2.941
C2	Lack of proper scope definition	4.008	4.103	3.710	4.138	3.972	4.211	4.000	3.882
C3	Lack of proper planning and control	4.212	4.276	4.065	4.241	4.111	4.053	4.370	4.176
C4	Lack of project strategic fit	3.780	3.897	3.677	3.655	3.722	3.737	3.891	3.647
C5	Lack of commitment of the project team	3.178	3.052	3.226	3.379	3.333	3.053	3.261	2.765
C6	Inadequate / lack of communication	3.771	3.707	3.710	3.966	3.750	3.684	3.761	3.941
C7	Improper management / leadership	3.771	3.690	3.613	4.103	3.917	3.632	3.783	3.588
C8	Inadequate / lack of project risk management	3.924	3.862	3.935	4.034	3.889	3.842	3.935	4.059
C9	Inadequate project organizational structure	3.653	3.638	3.581	3.759	3.556	3.684	3.739	3.588
C10	Inexperienced project team	3.695	3.724	3.484	3.862	3.750	3.474	3.674	3.882
C11	Lack of knowledge management	3.593	3.724	3.290	3.655	3.611	3.316	3.652	3.706
C12	Acts of god	2.890	2.931	2.903	2.793	2.861	2.842	2.978	2.765
C13	No acceptance by the local communities	2.958	2.966	2.968	2.931	3.028	2.737	3.174	2.471
C14	Uncontrolled environmental issues	3.729	3.879	3.677	3.483	3.694	3.895	3.674	3.765
C15	Failure in the cost estimation	4.254	4.448	4.161	3.966	4.222	3.947	4.391	4.294
C16	Lack of payment	3.568	3.655	3.387	3.586	3.667	3.842	3.565	3.059
C17	Failure in the supplier/subcontractor management	3.644	3.517	3.774	3.759	3.667	3.474	3.739	3.529
C18	Lack of supply management	3.483	3.517	3.258	3.655	3.528	3.158	3.630	3.353
All Prospective Root Causes		3.640	3.665	3.547	3.690	3.656	3.556	3.705	3.523

 Top Five Mean Values

Table 29 – Prospective Root Causes of Failure – Mean Values

4.4.2.6 Open Questions – Failure Rate and Root Causes of Failure

Two open questions, question 11 and question 12, were made available to respondents in the last page of the online questionnaire.

Question 11 asked the respondent's opinion (in %) about the failure rate of infrastructure construction projects in Brazil. The results observed for the failure rate regarding to the open question were the following:

In your opinion, what is the failure rate of infrastructure construction projects in Brazil ?	
<i>Measurements of Central Tendency</i>	<i>Value</i>
Mean (μ)	60.99%
Mode	50%
Median	60%
Standard Deviation	23.01%
People that Answered the Question	113
People that Skipped the Question	8

Table 30 – Open Question – Failure Rate of Infrastructure Construction Projects in Brazil

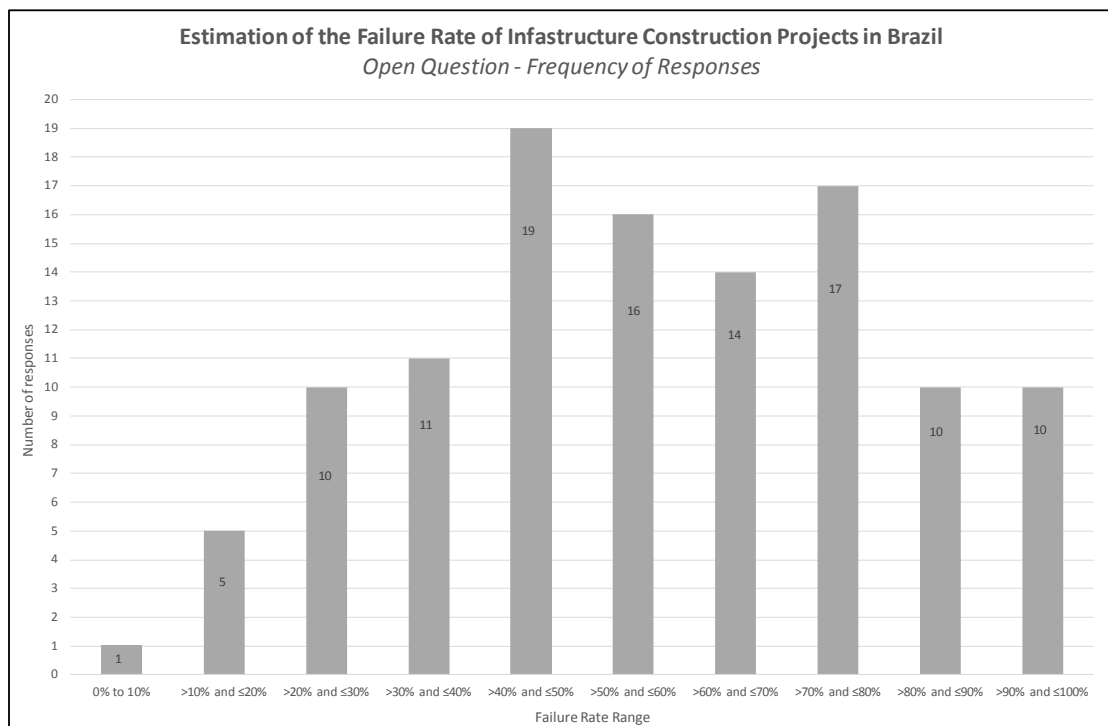


Figure 20 – Open Question – Estimation of the Failure Rate - Frequency of Responses

Question 12 inquired the respondents with an open text arrangement about the main root causes of failure of infrastructure construction projects in Brazil.

Since the question is an open text question, an interpretation is needed in order to analyse and present the results. This question will be interpreted according to the 18 prospective root causes of failure presented in the Table 17 and also new prospective root causes of failure will be created when needed.

The results observed for the root causes of failure in infrastructure construction projects in Brazil, in the question 12 (open question) for a sample of 107 respondents, were the following:

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Mentions	Score (100 base)
C1	Lack of project sponsor support	7	2.7%
C2	Lack of proper scope definition	62	23.7%
C3	Lack of proper planning and control	35	13.4%
C4	Lack of project strategic fit	1	0.4%
C5	Lack of commitment of the project team	4	1.5%
C6	Inadequate / lack of communication	3	1.1%
C7	Improper management / leadership	13	5.0%
C8	Inadequate / lack of project risk management	7	2.7%
C9	Inadequate project organizational structure	7	2.7%
C10	Inexperienced project team	15	5.7%
C11	Lack of knowledge management	5	1.9%
C12	Acts of god	1	0.4%
C13	No acceptance by the local communities	3	1.1%
C14	Uncontrolled environmental issues	12	4.6%
C15	Failure in the cost estimation	23	8.8%
C16	Lack of payment	6	2.3%
C17	Failure in the supplier/subcontractor management	11	4.2%
C18	Lack of supply management	4	1.5%
N1	Corruption	10	3.8%
N2	Inadequate supervision standards	3	1.1%
N3	Short development time	7	2.7%
N4	Inadequate Contract Model	6	2.3%
N5	Political issues and Bureaucracy	11	4.2%
N6	Lack of Finance	4	1.5%
N7	Unfair competition	2	0.8%
All Prospective Root Causes - Question 12		262	100.0%

Table 31 – Open Question – Root Cause for Failures – Frequency of Responses

Chapter 5. ANALYSIS AND CONCLUSIONS

5.1 Hypothesis Testing

The null and alternative hypothesis that will be tested are the ones declared in the chapter 2.3. The statements are the following:

- **H₀ statement:** Infrastructure construction projects in Brazil have a failure rate below or equal to 50%.
- **H_a statement:** Infrastructure construction projects in Brazil have a failure rate above 50%.

The hypothesis consists in one element, the failure rate of infrastructure construction projects in Brazil. Accordingly, hypothesis test shall be performed in this element based on the sample's result in the acceptance or rejection of the null hypothesis.

The data collected in question 8 among 724 infrastructure construction projects in Brazil was interpreted according to Merrow's (2011) threshold for failure in order to determine the failure rate of the researched sample. The result of this interpretation is shown in the Table 10 in the chapter 4.4.2.1 and demonstrates the percentage of infrastructure construction projects in Brazil that have failed, according to the comparison between the project information provided by the respondents and the thresholds for failure considered.

After measuring the failure rate of the researched infrastructure construction projects in Brazil, we are able to perform the hypothesis test of this sample proportion using a statistical test to compare it to the proportion stated in the null hypothesis.

For a single sample proportion hypothesis test, we could use a Z-test or a T-test to draw our conclusions. For a Z-test it is imperative that the population researched is greater than 30, what will tend to give a normally distributed curve. On the other hand, for a T-test the population researched can be lower than 30 and corrections will be made for the due to the non-normality of the distribution.

Since, in our case, the project's sample is 724, what is greater than 30, we will use the Z-test to perform the hypothesis test.

Rewriting the null and alternative hypothesis in mathematical terms, we have the following:

- For H_0 : $\rho \leq \rho_0$ or $\rho \leq 0.50$

- For H_a : $\rho > \rho_0$ or $\rho > 0.50$

Independent of the sample size being greater than 30, in order to perform the Z-test in the sample proportion found, the following assumptions and conditions must be valid:

- a) Condition 1 – Randomization Condition: Sample must be collected at random in order to represent the population;
- b) Condition 2 – 10% condition: Sample size must be less than 10% of the entire projects population (only for non-replaceable samples);
- c) Condition 3 - Success and Failure Condition: The sample must have at least 10 successes and 10 failures, so:

c.1: $n \times \rho \geq 10$

c.2: $n \times (1 - \rho) \geq 10$

For this hypothesis test, we have:

- Condition 1: OK – The projects population sample was randomly collected as explained in the chapter 4.2.3
- Condition 2: Non Applicable;
- a) Condition 3: OK – since for $\rho = 62.15\%$ and $n = 724$, we will have:

$$n \times \rho \geq 10 \qquad \rightarrow 724 \times 0.6215 \geq 10 \qquad \rightarrow 450 \geq 10 \text{ (OK)}$$

$$n \times (1 - \rho) \geq 10 \qquad \rightarrow 724 \times 0.3785 \geq 10 \qquad \rightarrow 274 \geq 10 \text{ (OK)}$$

Since we satisfy the three conditions to perform the Z-test, we will use the following equation to find the Z_{score} of the sample researched:

$$Z_{score} = \frac{\hat{\rho} - \rho_0}{\sqrt{\frac{\rho_0 \times (1 - \rho_0)}{n}}}$$

Where:

$\hat{\rho}$ = sample proportion

ρ_0 = hypothesis population proportion

n = sample size

Because of the inequation in the null hypothesis, we will turn this inequation in an equation in order to solve it. Therefore, using the maximum value of the inequation (worst-case scenario) we have:

- For $H_0: \rho_0 = 0.50$

The critical value of Z, or the $Z_{critical}$, in order to be compared with the Z_{score} found in the sample researched, will depend on the level of significance (α), that in this case will be equal to 0.05 or, in other terms, we will adopt 95% of confidence. Using a Z-value table for $\alpha = 0.05$, in the one tail test case, we have:

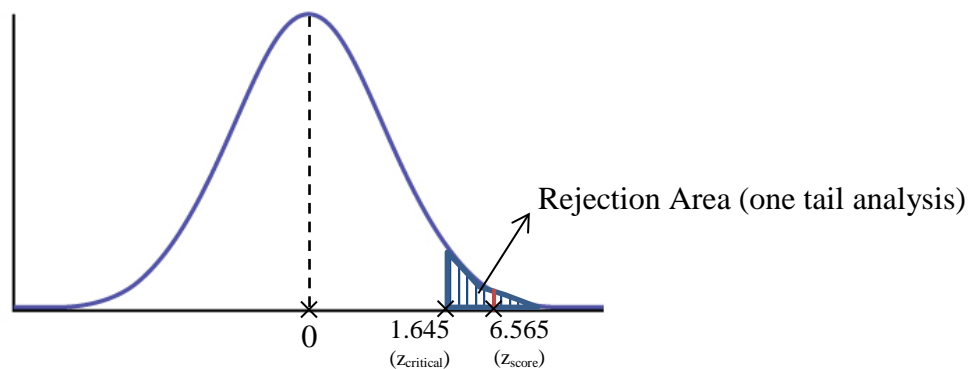
$$Z_{critical} = 1.645$$

Applying the Z_{score} formula for the sample researched, we have the following:

$$Z_{score} = \frac{\hat{p} - \rho_0}{\sqrt{\frac{\rho_0 \times (1 - \rho_0)}{n}}} = \frac{0.622 - 0.50}{\sqrt{\frac{0.50 \times (1 - 0.50)}{724}}} = \frac{0.122}{0.018582}$$

$$Z_{score} = 6.5654$$

If we plot the critical value of Z, based on the 5% level of significance in one tail and the Z_{score} in a normal distribution curve, we have the following:



Therefore:

Since $Z_{score} > Z_{critical}$ ($6.565 > 1.645$), we reject the null hypothesis and accept the alternative hypothesis proposed when analysing the failure rate based on Merrow's threshold for failure for the level of significance of 5%.

Analysing the Z_{score} found in the question 8 results (6.565) with the NORMSDIST excel function, for one tail test, it is possible to understand that we can reject the null hypothesis until the confidence level of 99.99999997%.

As an option for comparison, we can also use the results of question 11 (open question) where participants were requested to answer in their option what is the failure rate of infrastructure construction projects in Brazil. The results of this question are presented in the Table 30.

These results will be tested against the null and alternative hypothesis in the same way done by the interpretation of the question 8 results according to the Merrow's threshold for failure.

It is possible to test the responses of the question 11 against the normal distribution in order to understand if the data is normally distributed or not. Applying the Jarque-Bera and D'Agostino-Pearson tests, we had the following results:

Normality Test	p-value	Test Result for 95% of significance level
Jarque-Bera	0.181	OK
Shapiro -Wilk	0.009	<u>NOT OK</u>
D'Agostino-Pearson	0.169	OK
Anderson-Darling	0.013	<u>NOT OK</u>

Table 32 – Normality Test – Question 11 Data

Since the p-value of the Shapiro-Wilk and Anderson-Darling tests are lower than 0.05 (α) we cannot assume normality in the question 11 data. Based on that, question 11 data will be tested according to Student's T-test with n-1 degrees of freedom.

For the level of significance: 5% ($\alpha = 0.05$), in one tail test, with 112 degrees of freedom, we have:

$$T_{critical} = 1.659$$

For the sample collected among 113 respondents with standard deviation equal to 0.2301, we have the following equation in order to determine the T_{score} :

$$T_{score} = \frac{X - \mu}{\frac{S}{\sqrt{n}}} = \frac{0.6099 - 0.50}{\frac{0.2301}{\sqrt{113}}} = \frac{0.1099}{0.021642}$$

$$T_{score} = 5.0785$$

Since $T_{score} > T_{critical}$ ($5.0785 > 1.659$), we can reject the null hypothesis and accept the alternative hypothesis when analysing the failure rate based on question 11 responses to the level of significance of 5%.

Analysing the T_{score} found in the question 11 results (5.0785) with the TDIST excel function, for one tail test, it is possible to understand that we can reject the null hypothesis until the confidence level of 99.9999%.

5.2 Additional Research Questions

5.2.1 Segmentation of the Failure Rate

The failure rate found in the 724 projects sample in the question 8 was segmented according to the respondent's profile and also according to the type of infrastructure construction project. The segmentation results regarding to the failure rate are shown in the chapter 4.4.2.2.

As presented in the chapter 2.4, investigations will be made about the null hypothesis in the segmented failure rate of the question 8 results for the following questions:

- Question 2 – Segmentation by Position;
- Question 6 – Type of Respondent's Company; and
- Question 8 – Type of Infra Construction Project.

Similar to the null hypothesis analysis in the chapter 5.1, it will be conducted Z-tests regarding of the segmentation results found in the question 2.

It will be used the same level of significance (α) that is equal to 0.05 (or 95% of confidence). Therefore, for one tail test, we have:

$$Z_{critical} = 1.645$$

Before apply the Z-test on the segmented population samples, it will be verified the requirements needed for the Z-test be valid in these populations.

The table below summarizes the requirements for the Z-test and the situation of each one of the segmentations proposed.

Segmentation	Z-test Conditions			Z-test applicable?
	$n \geq 30$	$n \times p \geq 10$	$n \times (1-p) \geq 10$	
<i>Question 2 – Respondent’s Position</i>				
CEO, VP, Director	OK	OK	OK	Yes
Project Director	OK	OK	OK	Yes
Project Manager	OK	OK	OK	Yes
Professional	OK	OK	OK	Yes
<i>Question 6 – Type of Respondent’s Company</i>				
Contractor	OK	OK	OK	Yes
Project Owner	OK	OK	OK	Yes
Designer	OK	OK	OK	Yes
<i>Question 8 – Type of Infrastructure Construction Project</i>				
Transport/Logistics	OK	OK	OK	Yes
Power	OK	OK	OK	Yes
Telecommunication	Not OK	Not OK	Not OK	No
Water and Sewage	OK	OK	OK	Yes
Others	OK	OK	OK	Yes

Table 33 – Conditions for Z-test – Segmentation of the Failure Rate

The Z-test results for each segment, where it is possible to run such test, shown in the Table 34.

Segmentation	Z-test results		Reject the Null Hypothesis?	Maximum Level of Confidence (for one tail test)
	Z _{score}	Z _{critical}		
<i>Question 2 – Respondent’s Position</i>				
CEO, VP, Director	4.484	1.645	Yes	99,9996%
Project Director	2.377	1.645	Yes	99,128%
Project Manager	3.652	1.645	Yes	99,987%
Professional	2.157	1.645	Yes	98,451%
<i>Question 6 – Type of Respondent’s Company</i>				
Contractor	7,658	1.645	Yes	99,9999999999%
Project Owner	1,254	1.645	<u>Fail</u>	89,510%
Designer	1,271	1.645	<u>Fail</u>	89,807%
<i>Question 8 – Type of Infrastructure Construction Project</i>				
Transport/Logistics	5,280	1.645	Yes	99,99999%
Power	3,816	1.645	Yes	99,993%
Telecommunication	N/A	N/A	N/A	N/A
Water and Sewage	1,294	1.645	<u>Fail</u>	91,716%
Others	2,155	1.645	Yes	98,440%

Table 34 – Z-test results – Segmentation of the Failure Rate

An alternative for the hypothesis test of one sample proportion, when Z-test requirements are not met, as the case of Telecommunications projects (Table 33) with a total of 10 samples and failure rate of 60%, is the simple binomial distribution probability in order to verify the null hypothesis. The equation for the binomial distribution test is the following:

$$P(\text{type I error}) \geq 1 - B(c - 1; n; p_0) \rightarrow \text{For rejection of the null hypothesis}$$

Where:

c = critical value

p_0 = hypothesis population proportion

n = sample size

The significance level adopted (α) is 0.05 and critical value to be tested equal to 6 (60% of 10). Therefore:

$$\alpha \geq 1 - B(c - 1; n; p_0)$$

$$0.05 \geq 1 - B(c - 1; n; p_0)$$

$$0.05 \geq 1 - B(6 - 1; 10; 0.50)$$

$$0.05 \geq 1 - B(5; 10; 0.50)$$

$$0.05 \geq 1 - 0.623$$

$$0.05 \geq 0.377 \quad \rightarrow \quad \underline{\text{NOT OK, we cannot reject the null hypothesis.}}$$

Since $0.05 < 0.377$, we fail to reject the null hypothesis when analysing the failure rate of Telecommunication projects based on question 8 segmented responses for the level of significance of 5%.

5.2.2 Root Causes of Failure – Not Segmented

Concerning to the investigation of the root causes of failure in the infrastructure construction projects in Brazil, question 10 inquired the respondents, using five levels Likert scale as response options, about their opinion on 18 prospective root causes of failure derived from Camilleri (2011) factors of success and failure in projects. Chapter 4.4.2.4 shows the results regarding the responses for the 18 prospective root causes of failures.

In order to classify these 18 prospective root causes of failure, according to their importance, it will be used, as a first rule for the evaluation, the mean value of each prospective root causes presented in the Table 29.

It will be also presented the score points, in percentage, that each one of the 18 causes reached when compared to a total of 590 points possible (118 respondents multiplied by 5 points maximum per respondent).

Therefore, we have the following ranking:

#	Prospective Root Cause	Mean Value (μ)			
		Ranking	Mean Value	Std dev (σ)	Score Points (100 Base)
C15	Failure in the cost estimation	1	4.254	0.797	85.1%
C3	Lack of proper planning and control	2	4.212	0.749	84.2%
C2	Lack of proper scope definition	3	4.008	0.947	80.2%
C8	Inadequate / lack of project risk management	4	3.924	0.829	78.5%
C4	Lack of project strategic fit	5	3.780	0.839	75.6%
C6	Inadequate / lack of communication	6	3.771	0.881	75.4%
C7	Improper management / leadership	6	3.771	0.900	75.4%
C14	Uncontrolled environmental issues	8	3.729	1.051	74.6%
C10	Inexperienced project team	9	3.695	1.025	73.9%
C9	Inadequate project organizational structure	10	3.653	0.900	73.1%
C17	Failure in the supplier/subcontractor management	11	3.644	0.929	72.9%
C11	Lack of knowledge management	12	3.593	1.006	71.9%
C16	Lack of payment	13	3.568	1.158	71.4%
C18	Lack of supply management	14	3.483	0.894	69.7%
C1	Lack of project sponsor support	15	3.407	1.064	68.1%
C5	Lack of commitment of the project team	16	3.178	1.114	63.6%
C13	No acceptance by the local communities	17	2.958	0.982	59.2%
C12	Acts of god	18	2.890	0.959	57.8%

Table 35 – Prospective Root Causes of Failures – Ranked by the Mean Value

In order to verify if the mean value of these causes are ranked differently among each other, will be performed a One Way ANOVA test (also called one-way analysis of variance test). The test opens the possibility to analyse and test more than two population means, which means that it will be possible to verify, for example, if the prospective root causes C15, C3, C2, C8 and C4 have similar means or not, which will support the grouping/packing of the prospective root causes.

It is also possible to run a Welch's T-test for two population means, also called unequal variances t-test. The advantage of the T-test is that it does not require equal variances data, but its disadvantage is that allows only the comparison between two population means. If multiples Welch's T-test are applied to compare a group of sample means the probability of making a Type I error increases as the number of tests increase. For example, if the probability of a Type I error in the analysis is set at 0.05 and 10 Welch T-tests are done, the overall probability of a Type I error in the set of tests is 0.40^{11} instead of 0.05.

¹¹ Probability of Type I Error: $1 - (0.95)^{10} = 1 - 0.05987 = 0.4012$

In summary, the advantage of using ANOVA over multiple T-tests is that the ANOVA test will identify if any of the group means are significantly different from at least one of the other group means with a single test and by doing that it respects the level of significance used.

The classical One Way ANOVA test has the following main assumptions:

1. The dependent variable is normally distributed;
2. There is a homogeneity of variances;
3. Independence of observations;

The data for the root cause of failure respects the assumption 3 (independence of observations), but violates the assumptions 1 and 2, normal distributed data and homogeneity of variances respectively.

As an example, the first, second and third causes ranked in Table 35, C15 (Failure in the Cost Estimation), C3 (Lack of Proper Planning and Control) and C2 (Lack of Proper Scope Definition), were tested regarding to the normal distribution with the Shapiro-Wilk test and according to the homogeneity of the variances with the F-test. The results were the following:

✓ Shapiro-Wilk Test (Normality Test)

- C15: $p = 1.92 \times 10^{-12} < 0.05$ (Fail for 95% confidence level)
- C3: $p = 1.22 \times 10^{-11} < 0.05$ (Fail for 95% confidence level)
- C2: $p = 1.39 \times 10^{-10} < 0.05$ (Fail for 95% confidence level)

✓ F-Test - One tail (Homogeneity of Variances)

- C3 and C15: $F_{\text{score}} = 1.132 < F_{\text{critical}} = 1.357$ (Fail for 95% conf. level)
- C3 and C2: $F_{\text{score}} = 0.626 < F_{\text{critical}} = 0.737$ (Fail for 95% conf. level)
- C15 and C2: $F_{\text{score}} = 0.708 < F_{\text{critical}} = 0.737$ (Fail for 95% conf. level)

As an option to the Classical One Way ANOVA test, there is the Welch ANOVA Test, which is a robust test that does not require a normal distributed data, neither a homogeneity of variances and still allows the test of two or more mean groups.

In order to perform the Welch's ANOVA test among the groups of prospective root cause for failure, it was used the Real Statistics Resource Pack¹² for Microsoft Excel 2016.

The results of running the Welch's ANOVA test among the several groups of prospective root causes of failure are shown in the Table 36, Table 37, Table 38 and

¹² Available at <http://www.real-statistics.com/free-download/real-statistics-resource-pack/>

Table 39 next. Green values highlighted in the tables show the p-values greater than α (0.05) which means that the causes that were grouped and tested have the same mean value (same ranking position).

<i>p-values</i>	C15 ($\mu=4.25$)			
C3 ($\mu=4.21$)	0.674	0.081	0.005	0.00002
C2 ($\mu=4.01$)	-			
C8 ($\mu=3.92$)	-	-		
C4 ($\mu=3.78$)	-	-	-	

Table 36 – Prospective Root Causes of Failures – Position 1 with Welch ANOVA Test

<i>p-values</i>	C8 ($\mu=3.92$)										
C4 ($\mu=3.78$)	0.186	0.296	0.4253	0.485	0.472	0.339	0.280	0.186	0.136	0.019	0.0019
C6 ($\mu=3.77$)	-										
C7 ($\mu=3.77$)	-	-	-	-	-	-	-	-	-	-	
C14 ($\mu=3.73$)	-	-	-	-	-	-	-	-	-	-	
C10 ($\mu=3.69$)	-	-	-	-	-	-	-	-	-	-	
C9 ($\mu=3.65$)	-	-	-	-	-	-	-	-	-	-	
C17 ($\mu=3.64$)	-	-	-	-	-	-	-	-	-	-	
C11 ($\mu=3.59$)	-	-	-	-	-	-	-	-	-	-	
C16 ($\mu=3.57$)	-	-	-	-	-	-	-	-	-	-	
C18 ($\mu=3.48$)	-	-	-	-	-	-	-	-	-	-	
C1 ($\mu=3.41$)	-	-	-	-	-	-	-	-	-	-	

Table 37 – Prospective Root Causes of Failures – Position 2 with Welch ANOVA Test

<i>p-values</i>	C18 ($\mu=3.48$)			
C1 ($\mu=3.41$)	0.552	0.066	0.00013	0.000001
C5 ($\mu=3.18$)	-			
C13 ($\mu=2.96$)	-	-		
C12 ($\mu=2.89$)	-	-	-	

Table 38 – Prospective Root Causes of Failures – Position 3 with Welch ANOVA Test

<i>p-values</i>	C13 ($\mu=3.48$)
C12 ($\mu=2.89$)	0.592

Table 39 – Prospective Root Causes of Failures – Position 4 with Welch ANOVA Test

In summary, after the Welch’s ANOVA test with the prospective root causes of failure in infrastructure construction projects in Brazil, the ranking of these causes is divided into 4 levels (positions) that has the same mean value. The ranking is the following:

RANKING OF THE ROOT CAUSES FOR FAILURE			
Position 1	Position 2	Position 3	Position 4
C15	C8	C18	C13
C3	C4	C1	C12
C2	C6	C5	
	C7		
	C14		
	C10		
	C9		
	C17		
	C11		
	C16		

Figure 21 – Ranking of the Root Causes of Failures according to Welch ANOVA test

5.2.3 Root Causes of Failure – Segmented

As proposed in the chapter 2.4, the prospective root causes of failure will be segmented according to the responses of the question 6, type of respondent’s Company. Based on this segmentation of the responses regarding the root causes of failure, three analyses of the root causes of failure will be made, one for the option “Contractor”, another for the option “Investor/Project Owner”, and the last one for the option “Designer/Consultant”.

The sample size of each segment is the following:

- ✓ Contractor: 58 samples
- ✓ Investor/Project Owner 31 samples
- ✓ Designer/Consultant 29 samples

Based on the responses of each segmented group, the results ranked by the mean value, with standard deviation and score points are the following:

Segmentation per Respondent's Company - Contractor					
Cause #	Prospective Root Cause	Mean Value (μ)			Score Points (100 Base)
		Ranking	Mean Value	Std dev (σ)	
C15	Failure in the cost estimation	1	4.448	0.776	89.0%
C3	Lack of proper planning and control	2	4.276	0.812	85.5%
C2	Lack of proper scope definition	3	4.103	0.912	82.1%
C4	Lack of project strategic fit	4	3.897	0.831	77.9%
C14	Uncontrolled environmental issues	5	3.879	0.957	77.6%
C8	Inadequate / lack of project risk management	6	3.862	0.805	77.2%
C10	Inexperienced project team	7	3.724	1.089	74.5%
C11	Lack of knowledge management	7	3.724	0.988	74.5%
C6	Inadequate / lack of communication	9	3.707	0.859	74.1%
C7	Improper management / leadership	10	3.690	0.922	73.8%
C16	Lack of payment	11	3.655	1.264	73.1%
C9	Inadequate project organizational structure	12	3.638	0.931	72.8%
C17	Failure in the supplier/subcontractor management	13	3.517	1.047	70.3%
C18	Lack of supply management	13	3.517	0.960	70.3%
C1	Lack of project sponsor support	15	3.379	1.105	67.6%
C5	Lack of commitment of the project team	16	3.052	1.130	61.0%
C13	No acceptance by the local communities	17	2.966	1.126	59.3%
C12	Acts of god	18	2.931	1.024	58.6%

Table 40 – Prospective Root Causes of Failures – Contractor Segment Mean Results

Segmentation per Respondent's Company - Project Owner / Investor					
Cause #	Prospective Root Cause	Mean Value (μ)			Score Points (100 Base)
		Ranking	Mean Value	Std dev (σ)	
C15	Failure in the cost estimation	1	4.161	0.779	83.2%
C3	Lack of proper planning and control	2	4.065	0.772	81.3%
C8	Inadequate / lack of project risk management	3	3.935	0.892	78.7%
C17	Failure in the supplier/subcontractor management	4	3.774	0.762	75.5%
C2	Lack of proper scope definition	5	3.710	0.973	74.2%
C6	Inadequate / lack of communication	5	3.710	0.824	74.2%
C4	Lack of project strategic fit	7	3.677	0.909	73.5%
C14	Uncontrolled environmental issues	7	3.677	1.137	73.5%
C7	Improper management / leadership	9	3.613	1.022	72.3%
C9	Inadequate project organizational structure	10	3.581	0.923	71.6%
C10	Inexperienced project team	11	3.484	1.092	69.7%
C1	Lack of project sponsor support	12	3.419	1.057	68.4%
C16	Lack of payment	13	3.387	1.145	67.7%
C11	Lack of knowledge management	14	3.290	1.039	65.8%
C18	Lack of supply management	15	3.258	0.893	65.2%
C5	Lack of commitment of the project team	16	3.226	1.146	64.5%
C13	No acceptance by the local communities	17	2.968	0.948	59.4%
C12	Acts of god	18	2.903	0.790	58.1%

Table 41 – Prospective Root Causes of Failures – Investor Segment Mean Results

Segmentation per Respondent's Company - Designer / Consultant					
Cause #	Prospective Root Cause	Mean Value (μ)			Score Points (100 Base)
		Ranking	Mean Value	Std dev (σ)	
C3	Lack of proper planning and control	1	4.241	0.577	84.8%
C2	Lack of proper scope definition	2	4.138	0.953	82.8%
C7	Improper management / leadership	3	4.103	0.618	82.1%
C8	Inadequate / lack of project risk management	4	4.034	0.823	80.7%
C15	Failure in the cost estimation	5	3.966	0.778	79.3%
C6	Inadequate / lack of communication	5	3.966	0.981	79.3%
C10	Inexperienced project team	7	3.862	0.789	77.2%
C17	Failure in the supplier/subcontractor management	8	3.759	0.830	75.2%
C9	Inadequate project organizational structure	8	3.759	0.830	75.2%
C4	Lack of project strategic fit	10	3.655	0.769	73.1%
C11	Lack of knowledge management	10	3.655	0.974	73.1%
C18	Lack of supply management	10	3.655	0.721	73.1%
C16	Lack of payment	13	3.586	0.946	71.7%
C14	Uncontrolled environmental issues	14	3.483	1.122	69.7%
C1	Lack of project sponsor support	15	3.448	1.021	69.0%
C5	Lack of commitment of the project team	16	3.379	1.049	67.6%
C13	No acceptance by the local communities	17	2.931	0.998	58.6%
C12	Acts of god	18	2.793	1.013	55.9%

Table 42 – Prospective Root Causes of Failures – Designer Segment Mean Results

As executed in the general results of the root causes of failure (chapter 5.2.2), the Welch ANOVA test will be performed in the 18 causes of each one of the 3 segments in order to understand if the means ranked in the Table 40, Table 41 and Table 42 is equal or not among the groups of the 18 root causes researched.

In order to perform the Welch's ANOVA test among the groups of prospective root cause for failure, it was used the Real Statistics Resource Pack¹³ for Microsoft Excel 2016.

The results of the Welch ANOVA test for the Contractor segment are presented in the Table 43, Table 44 and Table 45 next. Green highlighted values in the tables means that the p-value of the Welch ANOVA test is greater than α (0.05), therefore it is possible to conclude that the means of the root causes analysed are equal, or, in other words, the ranking position of these root causes tested are the same.

¹³ Available at <http://www.real-statistics.com/free-download/real-statistics-resource-pack/>

<i>p-values</i>	C15 ($\mu=4.45$)			
C3 ($\mu=4,14$)	0,245	0,094	0,003	0,00089
C2 ($\mu=4,10$)	-			
C4 ($\mu=4,03$)	-	-		
C14 ($\mu=3,97$)	-	-	-	

Table 43 – Prospective Root Causes of Failures – Position 1 / Contractor Segment

<i>p-values</i>	C4 ($\mu=3.88$)											
C14 ($\mu=3,97$)	0,918	0,975	0,7984	0,771	0,736	0,736	0,760	0,718	0,508	0,348	0,135	0,001
C8 ($\mu=3,97$)	-											
C10 ($\mu=3,86$)	-	-	-	-	-	-	-	-	-	-		
C11 ($\mu=3,76$)	-	-	-	-	-	-	-	-	-	-		
C6 ($\mu=3,76$)	-	-	-	-	-	-	-	-	-	-		
C7 ($\mu=3,66$)	-	-	-	-	-	-	-	-	-	-		
C16 ($\mu=3,66$)	-	-	-	-	-	-	-	-	-	-		
C9 ($\mu=3,66$)	-	-	-	-	-	-	-	-	-	-		
C17 ($\mu=3,59$)	-	-	-	-	-	-	-	-	-	-		
C18 ($\mu=3,48$)	-	-	-	-	-	-	-	-	-	-		
C1 ($\mu=3,45$)	-	-	-	-	-	-	-	-	-	-		
C5 ($\mu=3,38$)	-	-	-	-	-	-	-	-	-	-		

Table 44 – Prospective Root Causes of Failures – Position 2 / Contractor Segment

<i>p-values</i>	C5 ($\mu=3.05$)	
C13 ($\mu=2,93$)	0,830	0,677
C12 ($\mu=2,79$)	-	

Table 45 – Prospective Root Causes of Failures – Position 3 / Contractor Segment

In summary, after the Welch's ANOVA test for the segment of the contractors, the ranking of the prospective root causes of failure in infrastructure construction projects in Brazil is divided into 3 levels (positions) that has the same mean value. The ranking for this specific segmented population is the following:

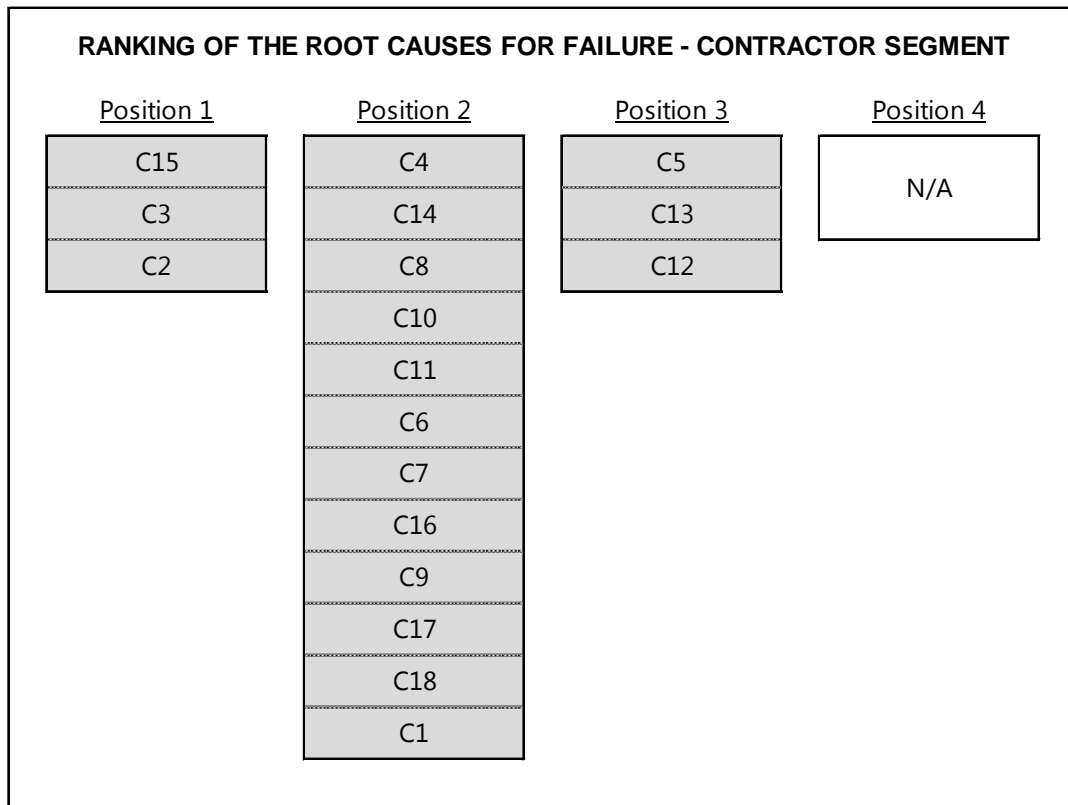


Figure 22 – Ranking of the Root Causes of Failures – Contractor Segment

The results of the Welch ANOVA test for the Investor / Project Owner segment are presented in the Table 46 and Table 47 next.

<i>p-values</i>	C15 ($\mu=4.16$)											
C3 ($\mu=4,14$)	0,625	0,576	0,241	0,187	0,151	0,138	0,160	0,146	0,115	0,082	0,045	0,028
C8 ($\mu=4,10$)	-											
C17 ($\mu=4,03$)	-	-	-	-	-	-	-	-	-	-		
C2 ($\mu=3,97$)	-	-	-	-	-	-	-	-	-	-		
C6 ($\mu=3,97$)	-	-	-	-	-	-	-	-	-	-		
C4 ($\mu=3,86$)	-	-	-	-	-	-	-	-	-	-		
C14 ($\mu=3,76$)	-	-	-	-	-	-	-	-	-	-		
C7 ($\mu=3,76$)	-	-	-	-	-	-	-	-	-	-		
C9 ($\mu=3,66$)	-	-	-	-	-	-	-	-	-	-		
C10 ($\mu=3,66$)	-	-	-	-	-	-	-	-	-	-		
C1 ($\mu=3,66$)	-	-	-	-	-	-	-	-	-	-		
C16 ($\mu=3,59$)	-	-	-	-	-	-	-	-	-	-		

Table 46 – Prospective Root Causes of Failures – Position 1 / Investor Segment

<i>p-values</i>	C1 ($\mu=3.42$)					
C16 ($\mu=3,59$)	0,909	0,882	0,911	0,946	0,564	0,231
C11 ($\mu=3,48$)	-					
C18 ($\mu=3,45$)	-	-	-	-	-	
C5 ($\mu=3,38$)	-	-	-	-	-	
C13 ($\mu=2,93$)	-	-	-	-	-	
C12 ($\mu=2,79$)	-	-	-	-	-	

Table 47 – Prospective Root Causes of Failures – Position 2 / Investor Segment

In summary, after the Welch’s ANOVA test for the segment of the Investors / Project Owners, the ranking of the prospective root causes of failure in infrastructure construction projects in Brazil is divided into 2 levels (positions) that has the same mean value. The ranking for this specific segmented population is the following

RANKING OF THE ROOT CAUSES FOR FAILURE - INVESTOR SEGMENT			
<u>Position 1</u>	<u>Position 2</u>	<u>Position 3</u>	<u>Position 4</u>
C15	C1	N/A	N/A
C3	C16		
C8	C11		
C17	C18		
C2	C5		
C6	C13		
C4	C12		
C14			
C7			
C9			
C10			

Figure 23 – Ranking of the Root Causes of Failures – Investors Segment

The results of the Welch ANOVA test for the Designer / Consultant segment are presented in the Table 48, Table 49 and Table 50 next.

<i>p-values</i>	C3 ($\mu=4.24$)										
C2 ($\mu=4,14$)	0,619	0,671	0,699	0,613	0,659	0,487	0,265	0,173	0,057	0,039	0,017
C7 ($\mu=4,10$)	-										
C8 ($\mu=4,03$)	-										
C15 ($\mu=3,97$)	-										
C6 ($\mu=3,97$)	-										
C10 ($\mu=3,86$)	-										
C17 ($\mu=3,76$)	-										
C9 ($\mu=3,76$)	-										
C4 ($\mu=3,66$)	-										
C11 ($\mu=3,66$)	-										
C18 ($\mu=3,66$)	-										

Table 48 – Prospective Root Causes of Failures – Position 1 / Designer Segment

<i>p-values</i>	C11 ($\mu=3.66$)						
C18 ($\mu=3,66$)	1,000	0,946	0,906	0,885	0,837	0,020	0,001
C16 ($\mu=3,59$)	-						
C14 ($\mu=3,48$)	-						
C1 ($\mu=3,45$)	-						
C5 ($\mu=3,38$)	-						
C13 ($\mu=2,93$)	-						
C12 ($\mu=2,79$)	-						

Table 49 – Prospective Root Causes of Failures – Position 2 / Designer Segment

<i>p-values</i>	C13 ($\mu=2.93$)
C12 ($\mu=2,79$)	0,567

Table 50 – Prospective Root Causes of Failures – Position 3 / Designer Segment

In summary, after the Welch’s ANOVA test for the segment of the Designers / Consultants, the ranking of the prospective root causes of failure in infrastructure construction projects in Brazil is divided into 3 levels (positions) that has the same mean value. The ranking for this specific segmented population is the following

RANKING OF THE ROOT CAUSES FOR FAILURE - DESIGNER SEGMENT			
Position 1	Position 2	Position 3	Position 4
C3	C11	C13	N/A
C2	C18	C12	
C7	C16		
C8	C14		
C15	C1		
C6	C5		
C10			
C17			
C9			
C4			

Figure 24 – Ranking of the Root Causes of Failures – Designers Segment

5.3 Intermediate Conclusions

The failure rate proportions tested for the null hypothesis stated in the chapter 2.3, with a confidence level of 95%, presents the following summarized results:

Failure Rate Case	Sample Size	Failure Rate	Type of Test	Reject Null Hypothesis?	Maximum p_0 for h_0 rejection
<i>Not Segmented</i>					
Project Sample (Q8)	724	62.15%	Z-test	Yes	59.14%
Open Question (Q11)	113	60.99%	T-test	Yes	57.40%
<i>Q8 Results Segmented According to Question 2 – Respondent’s Position</i>					
CEO, VP, Director	230	64.78%	Z-test	Yes	59.46%
Project Director	129	60.47%	Z-test	Yes	53.24%
Project Manager	261	61.30%	Z-test	Yes	56.25%
Professional	104	60.58%	Z-test	Yes	52.52%
<i>Q8 Results Segmented According to Question 6 – Type of Respondent’s Company</i>					
Contractor	339	70.80%	Z-test	Yes	66.58%
Investors	206	54.37%	Z-test	No	<u>48.64%</u>
Designer	179	54.75%	Z-test	No	<u>48.60%</u>

Failure Rate Case	Sample Size	Failure Rate	Type of Test	Reject Null Hypothesis?	Maximum p ₀ for h ₀ rejection
<i>Q8 Results Segmented According to Type of Infrastructure Construction Project</i>					
Transport/Logistics	161	70.81%	Z-test	Yes	61.61%
Power	356	60.11%	Z-test	Yes	55.78%
Telecommunications	10	60.00%	Binomial	No	<u>30.35%</u>
Water and Sewage	102	56.86%	Z-test	No	<u>48.72%</u>
Others	382	66.23%	Z-test	Yes	52.63%

Table 51 – Failure Rate Summary Table – Hypothesis Tests Results

Based on the statistical tests performed in the failure rate data of the primary research, the null hypothesis stated in the chapter 2.3, have been rejected for the results of the non-segmented data of either question 8 and 10 to 95% of confidence level.

After segmenting the failure rate data, gathered from the interpretation of the question 8 responses based on thresholds for failure (Merrow, 2011), in some segments was not possible to reject the null hypothesis according to the tests performed with 95% of confidence level. The segments that we fail to reject the null hypothesis are the following:

- Failure rate of the Question 8 segmented according to Question 6
 - Segment – Investors / Project Owner
 - Segment – Designers / Consultants
- Failure rate of Question 8 segmented according to Type of Infra Project
 - Segment – Telecommunications Projects
 - Segment – Water and Sewage Projects

Although was not possible to reject the null hypothesis for the telecommunications projects segment, only 10 samples were available to perform the statistical test of the failure rate found. This small number of samples can lead to a wrong acceptance of the null hypothesis.

The root causes of failure, gathered from the responses of the question 10 tested according to Welch's ANOVA test, have been analysed for the general case (full data) and segmented cases. The segmented data of question 10 were based on the question 6 responses (type of company), what leads us to build three rankings of the prospective root cause for failure.

In addition, the root causes of failure data in the question 12, the open question that gave the opportunity to the respondents to write what they consider as the main root causes of failure for infrastructure construction projects in Brazil, was interpreted and analysed in the chapter 4.4.2.6.

In summary, the most important prospective root causes were grouped according to the Welch’s ANOVA Test and the position 1 of this grouping is shown in the Figure 25 next.

POSITION 1 - ROOT CAUSES FOR FAILURE (QUESTION 10)				
General 118 samples	Contractor Segment 58 samples	Investor Segment 31 samples	Designer Segment 29 samples	Open Question (Q12)* 107 samples
C2	C2	C2	C2	C2
C3	C3	C3	C3	C3
C15	C15	C15	C15	C15
		C8	C8	
		C7	C7	
		C6	C6	
		C4	C4	
		C17	C17	
		C9	C9	
		C10	C10	
		C14		

* Top 3 causes mentioned in the question 12 (open question)

Figure 25 – Root Causes of Failures – Summary for the Positon 1

The results of the statistical tests in the data on the root causes of failure, with 95% of confidence level, were consistent in the general case (for the full sample), in the open question results and in the three segments investigated.

All analysis showed that at least three causes are definitely positioned as the main root causes of failure of the infrastructure construction projects in Brazil. These causes are:

- (C2) Lack of proper scope definition;
- (C3) Lack of proper planning and control;
- (C15) Failure in the cost estimation.

The segments of “Investors” and “Designers”, with a reduced sample when compared to the other groups, also placed more seven root causes as the main root causes for failure. These seven causes are:

- (C8) Inadequate / lack of project risk management;
- (C7) Improper management / leadership;

- (C6) Inadequate / lack of communication;
- (C4) Lack of project strategic fit;
- (C17) Failure in the supplier/subcontractor management;
- (C9) Inadequate project organizational structure;
- (C10) Inexperienced project team.

The segment “Investors” was the only one to include the C14 (uncontrolled environmental issues) in the main root causes for failure.

When analysing the results of the general case and the contractor segment, we can identify that the seven causes appointed only by investors and designers as part of the main root causes for failure are placed in the group of the “Position 2” (Figure 21 and Figure 22). Even the C14, elected only by the investors as part of the main root causes for failure is in the position 2 for the general case and contractor segment.

When analysing the results of the open question (question 12) the causes C10, C7, C14, C17, C8 and C9 are ranked between 4th and 9th position, exactly after the main root causes for failure C2, C3, and C15 that occupies the 1st, 2nd and 3rd position respectively as the most mentioned main root causes for failure of infrastructure construction projects in Brazil.

Therefore, we can affirm that for the total population researched, the main root causes of failure of the infrastructure construction projects in Brazil are the following:

- (C2) Lack of proper scope definition;
- (C3) Lack of proper planning and control;
- (C15) Failure in the cost estimation.

Based also on the question 12, seven other causes, out of the original 18 prospective root causes of failure (Table 17), have been mentioned as the main root causes of failure. These new causes, their position regarding to the 25 causes identified in the question 12, is the following:

Cause #	Prospective Root Causes for Infrastructure Construction Project Failure - Brazil	Number of Mentions	Score (100 base)	Ranking (25 total)
N1	Political issues and Bureaucracy	11	4.2%	7
N2	Corruption	10	3.8%	9
N3	Short development time	7	2.7%	10
N4	Inadequate Contract Model	6	2.3%	14
N5	Lack of Finance	4	1.5%	17
N6	Inadequate supervision standards	3	1.1%	20
N7	Unfair competition	2	0.8%	23
All Prospective Root Causes - Question 12		262	100.0%	

Table 52 – Complementary Prospective Root Causes of Failure – Open Question

Chapter 6. CONCLUSIONS

6.1 Summary of the Findings

The primary data was collected through an online survey between May-30th, 2016 and June-19th, 2016 distributed among 400 random engineering and construction sector professionals that had previous experience with infrastructure construction projects in Brazil. The online questionnaire was accessed by 135 respondents, and received input from 121 respondents with previous experience with infrastructure construction projects in Brazil.

The questionnaire was designed to collect information about the failure rate of infrastructure construction projects in Brazil and its main root causes. Using Merrow (2011) thresholds for failure as a baseline for the project failure definition, the questionnaire collected information about 724 infrastructure construction projects in Brazil (question 8). On the other hand, the questionnaire also collected information in an open question (question 11) of the respondent's opinion about the failure rate of this type of project in Brazil.

The theoretical framework of project failure developed by Merrow (2011), based on 318 industrial mega projects worldwide, suggests that a project shall be considered as a failure when it reaches one, or more, of these five thresholds:

- (1) Cost overruns > 25%
- (2) Cost competitiveness > 25%
- (3) Slip in execution schedule > 25%
- (4) Schedule competitiveness > 50%
- (5) Actual production versus planned: Significant reduced production into year 2

The competitiveness dimension, items (2) and (4) of the Merrow's thresholds for failure, involves the comparison of the project's cost and schedule baselines with similar projects in the market at the time of full funds authorization and determine if the project baselines exceeds the market standard conditions. In order to be able to answer a question about cost and schedule competitiveness, the respondent shall be knowledgeable not only about the project itself but also about the entire market conditions at that time. An error in the collection of this type of competitiveness data could lead to misinterpretation of the reality and cause an extensive error in the estimation of the project failure rate. For this reason, the questionnaire was designed to

collect categorical information, Yes or No, for infrastructure construction projects in Brazil about the Merrow's threshold for failure (1), (3) and (5) of the list above.

The root causes data was collected in the questions 10 and 12 of the questionnaire. Question 10 requested the respondent's opinion, in line with a five level Likert scale options, about the 18 prospective root causes of failure, showed in the Table 17 and developed according to the list of success and failure factors for projects (Camilleri, 2011).

An open question (question 12) also collected respondent's information about their opinion of the main root causes of failure of infrastructure construction projects in Brazil. The results of this open question were interpreted according to the 18 prospective root causes of failure presented in the Table 17. Additional prospective root causes had been designed in order to fully capture and analyse the responses to this open text questions.

6.1.1 Failure Rate Findings

In the chapter 5.1 the null hypothesis stated in the chapter 2.3 was tested against the failure rate data of 724 projects (question 8) and the opinion of 113 respondents (question 11) also regarding to the failure rate of infrastructure construction projects.

The question 8 data, here called project data, was also segmented according to the parameters defined in the chapter 2.4. These parameters are:

1. Question 2 – Segmentation by Position
 - 1.1. CEO, VPs and Directors segment
 - 1.2. Project Director segment
 - 1.3. Project Manager / Team Leader segment
 - 1.4. Professional segment
2. Question 6 – Type of Respondent's Company
 - 2.1. Contractor;
 - 2.2. Investor / Project Owner;
 - 2.3. Designer / Consultant
3. Question 8 – Type of Infra Construction Project
 - 3.1. Transport / Logistics
 - 3.2. Power
 - 3.3. Telecommunications
 - 3.4. Sewage and Water systems

3.5. Other infrastructure projects

Next table summarizes the failure rate proportions tested for the null hypothesis stated in the chapter 2.3, with a confidence level of 95%.

Failure Rate Case	Sample Size	Failure Rate	Type of Test	Reject Null Hypothesis?	Maximum p ₀ for h ₀ rejection
<i>Not Segmented</i>					
Project Sample (Q8)	724	62.15%	Z-test	Yes	59.14%
Open Question (Q11)	113	60.99%	T-test	Yes	57.40%
<i>Q8 Results Segmented According to Question 2 – Respondent’s Position</i>					
CEO, VP, Director	230	64.78%	Z-test	Yes	59.46%
Project Director	129	60.47%	Z-test	Yes	53.24%
Project Manager	261	61.30%	Z-test	Yes	56.25%
Professional	104	60.58%	Z-test	Yes	52.52%
<i>Q8 Results Segmented According to Question 6 – Type of Respondent’s Company</i>					
Contractor	339	70.80%	Z-test	Yes	66.58%
Investors/Proj Owner	206	54.37%	Z-test	No	<u>48.64%</u>
Designer/Consultant	179	54.75%	Z-test	No	<u>48.60%</u>
<i>Q8 Results Segmented According to Type of Infrastructure Construction Project</i>					
Transport/Logistics	161	70.81%	Z-test	Yes	61.61%
Power	356	60.11%	Z-test	Yes	55.78%
Telecommunications	10	60.00%	Binomial	No	<u>30.35%</u>
Water and Sewage	102	56.86%	Z-test	No	<u>48.72%</u>
Others	382	66.23%	Z-test	Yes	52.63%

Table 53 – Infrastructure Construction Project Failure Rate – Summary

Based on the statistical tests made for the projects data (question 8) and for the open question data (question 11), we can reject the proposed null hypothesis and accept the alternative hypothesis that is the following: “**Infrastructure construction projects in Brazil have a failure rate above to 50%**”

In the segmented results of the failure rate, we fail to reject the null hypothesis to the Investor/Project Owner and Designer/Consultants segments. In summary, when the results of the failure rate are segmented by the type of the company that the respondent have more experience, respondents from the investor side and also from the

designer side experienced less problematic projects during their careers when compared to the respondents that have worked more frequently for the contractors.

Analysing the segmentation of the failure rate based on the type of infrastructure projects data, we also fail to reject the null hypothesis for Telecommunication projects and Water and Sewage Systems projects. Regarding to the telecommunications project the analysis was based on only 10 projects and with this small sample, of only categorical information (fail / not fail), the likelihood of committing Type I and/or Type II errors in the hypothesis test increases substantially.

In summary, regarding to the segmentation of the failure rate by type of infrastructure projects, it is possible to conclude that infrastructure projects with more standardized scopes fail less than infrastructure projects that are highly dependable of site studies, like highways, bridges, hydropower plants¹⁴, urban public buildings and other type of public systems excluding water and sewage. These site studies, like topography survey, geological and geotechnical survey, are expensive and time-consuming studies that shall be executed before the contractor mobilization in order to better determine the project scope.

6.1.2 Main Root Causes of Failures Findings

The 18 prospective root causes of failure (Table 17) have been submitted to a survey using a five level Likert scale (question 10) in order to select the main causes according to Welch's ANOVA test on the mean value of the respondent's opinion. A second question, question 12, was also designed to collect information about the main root causes for failure of infrastructure construction projects in Brazil allowing the respondent to freely write his opinion on the topic. In the end, the results of question 10, for the general case and for the segmented case, according to the respondent's type of company where compared among each other and also with the results of the question 12 in order to reach a conclusion about the main root causes of failures for this type of project. The results of the tier 1 of the root causes of failure in each case are shown in the next figure.

¹⁴ According to the Brazilian government website, hydropower plants were responsible for 77.1% of the power produced in Brazil in 2010.

POSITION 1 - ROOT CAUSES FOR FAILURE (QUESTION 10)				
General 118 samples	Contractor Segment 58 samples	Investor Segment 31 samples	Designer Segment 29 samples	Open Question (Q12)* 107 samples
C2	C2	C2	C2	C2
C3	C3	C3	C3	C3
C15	C15	C15	C15	C15
		C8	C8	
		C7	C7	
		C6	C6	
		C4	C4	
		C17	C17	
		C9	C9	
		C10	C10	
		C14		

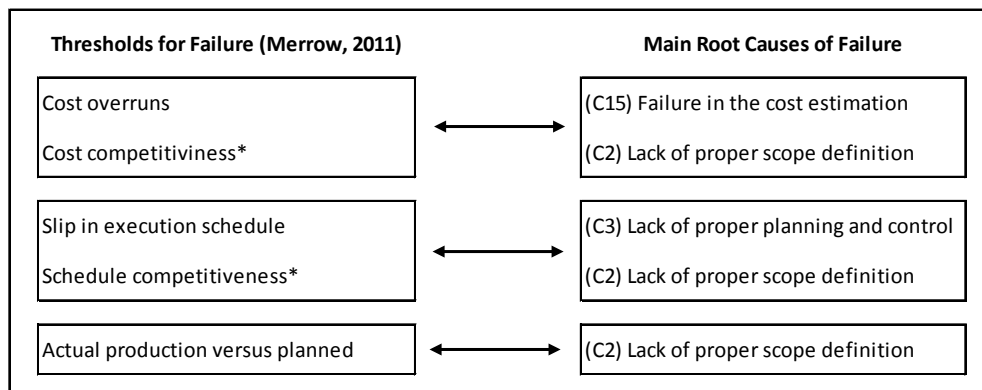
* Top 3 causes mentioned in the question 12 (open question)

Figure 26 – Main Root Causes of Failures

The causes C2, C3 and C15 are grouped in the general case and in the contractor segment as the main root causes for failure. These three causes were also selected by investors and designers, but are not alone in this segment. The open question also captured the same tendency since the three most frequent causes mentioned was also C2, C3, and C15. These main root causes of failure are the following:

- (C2) Lack of proper scope definition;
- (C3) Lack of proper planning and control;
- (C15) Failure in the cost estimation.

The main root causes of failure are directly related to the thresholds for failure used to identify the projects that have failed (Merrow 2011). The relationship between the main root causes for failure found and the thresholds for failure is exposed in the Figure 27.



* Not researched

Figure 27 – Relationship between Threshold for Failure and Root Causes of Failures

6.2 Overall Conclusion

In order to research the failure rate of infrastructure construction projects in Brazil, a random walk approach was adopted establishing a null hypothesis for the failure rate for this type of project as being equal to 50% or less (chapter 2.3).

The primary research showed that in general 62.15% of the infrastructure construction projects in Brazil have failed, according to the thresholds for failure (Morrow, 2011). A hypothesis test has performed in this sample proportion researched where we **rejected the null hypothesis and accept the alternative hypothesis that the failure rate of this type of project in Brazil is greater than 50%**. Due to confidentiality and anonymity principles, for these 724 infrastructure projects researched, was not asked the name neither the date of the beginning and conclusion of these projects.

Since 62.15% of the infrastructure construction projects fail in Brazil, and one of the thresholds to determine this condition is the cost overrun greater than 25%, we can assume that, from the total investment in infrastructure projects in Brazil, at least 15.5%¹⁵ of the investments are wasted and do not generate any additional value to the society and project stakeholders. Using BMI Research estimations for 2015, where the investments in infrastructure in Brazil were USD 316.9 billion (Figure 3), the minimum economical waste can be estimated at USD 50 billion dollars.

According to Calderón, Moral-Benito and Servén (2014) the elasticity of the country's GDP to the infrastructure asset value lies in between 0.07 and 0.10, what means that each 10% increase on the infrastructure asset value, the GDP will grow between 0.7% and 1.0%. Therefore, we can conclude that, the minimum impact of the failure rate in the Brazilian GDP is in between 1.1% and 1.6% per year.

Nevertheless, comparing this result with the failure rate found in the open question, where the respondents have been asked their opinion of the current failure rate of infrastructure construction projects in Brazil, the result was 60.99%, allowing us to conclude that the failure rate today (60.99%), according to the opinion of the respondents, is very similar to the historical failure rate found based on project data (62.15%). It is possible to conclude also that the poor historical performance of infrastructure construction projects in Brazil does not differ from the reality today.

¹⁵ Minimum economical waste level: $62.15\% \times 25\% = 15.54\%$ of the total infrastructure investments in Brazil.

The segmentation of the failure rate based on project historical data showed that professionals working for investors and designers experienced a lower failure rate than professionals working for the contractor. The reason why contractors have experienced more problematic projects than investors or designers is certainly in the contractual arrangement that these companies are submitted. Even though it is more expensive, investors usually hire contractors using an EPC / Turnkey¹⁶ contractual arrangement, especially for high-risk projects as infrastructure projects. Investors do this in a way to protect themselves from higher costs due to changes in the original scope, transferring most of the engineering risks to the contractors. On the other hand, designers and consultants are usually hired based on the hours spent to perform a specific service. Even though the investor usually asks for a lump sum price, the designers and the consultants are able to define better the hours that will be spent and have the flexibility, if needed, to change senior people by junior employees to cut costs or even cut hours from the service and still deliver what has been agreed contractually.

In a sector characterized by a frequent risk transfer from the project owner/investor to the contractor, it is expected that the contractor will observe more cost overruns without being able contractually to transfer these costs to the investor since they are under an EPC/Turnkey contractual arrangement. Even if analysed the slip in the execution schedule, with a contractor's perspective, this execution delay will be transformed into cost overrun because to avoid massive contractual penalties due to this delay, the contractor tends to increase its resources during the construction or even will opt to work during the night shift to recover the contractual deadlines. These results, regarding to the contractor population, confirms the popular saying in the Brazilian construction sector that “*projects are not finished, projects are abandoned*”.

Analysing the segmentation of the failure rate based on project historical data for the different types of infrastructure projects, it was not possible to reject the null hypothesis for telecommunications projects and water and sewage systems projects. Even though we have analysed only 10 samples for the telecommunication projects, the reason is that among the infrastructure projects, telecommunications have the most well defined scope of works, without the need to execute extensive site works to define its scope in details. According to Table 53, we could reject a null hypothesis for

¹⁶ EPC/Turnkey is a contract arrangement where the contractor is responsible for engineering, procurement and construction assuming a fixed lump sum price, handing over the project, already commissioned and in operation, to the owner.

telecommunication projects, if this null hypothesis stated a failure rate equal or below 30%, what gives the idea that telecommunication projects tend to have similar failure rates as IT projects according to numbers published in the chaos manifesto (The Standish Group, 2013).

Following the same train of thoughts, the fail to reject the null hypothesis for Water and Sewage Systems infrastructure projects, supports the idea that projects with more standardized scope like telecommunications, water and sewage, tend to fail less than projects with limited scope standardization, what is the case of Power¹⁷ and Transport/Logistics infrastructure projects that are the ones with higher failure rate and higher non-standardized engineering solutions, higher interface with deep foundation works and also commonly built in remote locations.

Regarding to the main root causes of failure of infrastructure construction projects in Brazil, the research identified three specific causes that according to a Welch's ANOVA test, are equally ranked on the top of the list and can be designated as the main root causes of failure. These causes are the following:

- (C2) Lack of proper scope definition;
- (C3) Lack of proper planning and control;
- (C15) Failure in the cost estimation.

The results confirm what has been observed in the failure rate research (general and segmented cases), where scope, time and cost definition are the most important project dimensions to avoid project failure. These three main root causes of failure identified are closely related to the thresholds for failure (Figure 27) and also form what is called the triple constraint (Figure 8), that are the most important restrictions that the project managers need to deal.

These three causes can be present and influence all phases of the project, from the business case definition of the execution and operation, but according to the results of question 9, the phase that most contribute to the failure of infrastructure construction projects in Brazil is the "Development Phase" according to 59.3% of the 118 respondents. This phase is where the cost, time and scope baselines are defined and the investor will approve the investment based on an internal rate of return (IRR) or a net present value (NPV) of the investment.

¹⁷ In Brazil, almost 70% of the total power produced came from hydroelectric power plants in 2015.

It is clear that the massive failure rate found in this research has its roots mainly in the misconceptions in the scope, time and cost baselines in the early phases of the project. The execution phase, which is one of the most targeted and complex phase of an infrastructure project, has no power, and will not, solve the problems related to scope, time and cost baselines, inherited from the development phase.

In addition, as discussed in the segmented failure rate by type of company, even when the investor transfers the risk to the contractor through an EPC Turnkey contractual arrangement, the project could not fail based on the investors or designer's perspective but it will fail when analysed through the thresholds for failure based on the contractor's perspective. This reality shall be reflected in the amount of contractual claims presented by contractors and is an interesting future research topic.

In fact, the three main root causes of failure found are intrinsically connected, since the lack of scope definition imperatively leads the project to experience poor schedule and cost baselines. The opposite can happen, but in practice, it is uncommon. Based on that, scope definition during the development phase shall remain as the most important activity of the project and the one who has the biggest economic impact in infrastructure construction projects. For this reason, a well-dimensioned and well-executed field studies campaign, that will allow the technical team to define the scope with the highest possible level of details in the early stages of the projects, is the key element to avoid project failure in infrastructure construction projects. As an example of these field studies, we can mention:

- Geological survey;
- Geotechnical survey;
- Topographical survey;
- General mapping and site reconnaissance;
- Hydrological survey;
- Connection studies;
- Identification of natural deposits for raw material exploitation, etc.

Starting from a well-defined scope of works for the infrastructure construction project, the probability of a mistake in the schedule and in the cost estimate is massively minimized. When the scope is not defined properly in the early stages of the project, the conditions are in place to a scope creep during the later stages of the project. Scope creep are the two dirtiest words in construction project management and are used to define a situation where the project scope grows continually and uncontrolled during

the construction phase. Passively accept the risk of a project passing through a situation like that is flirting with an economic disaster and a certain project failure.

Besides the problem regarding to the scarcity of a site information to better define the project scope and establish a real baseline for the costs and schedule of the project, professionals are frequently affected by a positive cognitive bias that leads the production of an over optimistic scenario that is generally inadequate for the project (Lovallo & Kahneman, 2003). Nevertheless, Flyvbjerg (2003) commenting on Lovallo & Kahneman's (2003) article added that professionals may suffer from a positive cognitive bias, but sometimes they are deliberately "cooking" the forecasts in order to get ventures started. Flyvbjerg (2003) calls this the "Machiavelli factor". This will be discussed in details in the chapter 6.4, the Ethical Implications. However, this specific topic deserves a separated research in order to be widely analysed in the context of project failure.

On the other hand, analysing the least important prospective root causes of failure, it gives us some important insights, especially regarding to the uncontrollable variables of the project. At the bottom of the root causes of failure list, for the general case (Figure 21), we can observe C13 and C12. According to the Table 17, these causes are the following:

- (C12) Acts of god; and
- (C13) No acceptance by the local communities.

Coincidentally, acts of god, or force majeure, is a very common justification in the market for delays and cost overruns, since it is an uncontrollable variable. If this situation happens in a project, will certainly cause delays and extra costs in order to recover the original baselines, and sometimes, acts of god, as if flooding, natural disaster and excess of rain, can destroy the construction site.

The research did not recognize the variable "acts of god" as one of the most important causes of the infrastructure project failure, since from all the factors that can influence a project failure, this cause specifically, was ranked in the last position, together with another uncontrolled variable that is the no acceptance of the project by the local communities. The conclusion is obvious and short; project failure is undoubtedly under the control of the project team, the management and the project sponsor(s).

In the open question, that investigated the root causes of failure (question 12), respondents gave also some additional causes that were not listed in the original 18

prospective root causes of failure. From these complementary root causes of failure list (Table 52) it is interesting to analyse the better positioned one, the N1 (Political issues and Bureaucracy) and the N2 (Corruption) since both coincidentally refers to government interactions with the private sector.

Definitely, there is an ethical implication of this specific finding. Not only ethical, but also regarding the corruption there is a criminal case. On the other hand, these causes were not ranked on the top of the root causes list in the question 12. Based on that, we can conclude that if these causes were included in the in the original 18 prospective roots causes researched on question 10, they will certainly reach some intermediary position, meaning that, they exist, they impact, but they are not the main issues faced in infrastructure construction projects in Brazil. It is important to point that Brazil is experiencing today a political crisis derived from one of the biggest corruption scandals in the world. This situation naturally leads to a bias in the open text responses and to confirm the real position of these governmental issues in the failure of infrastructure construction projects, a new research will be needed at an appropriate time.

6.3 Recommendations

In order to reduce the probability of a failure in an infrastructure construction project, companies must adopt governance principles that will guarantee that these projects will be developed according to the best practices in the market and aligned with the risk level that the shareholders want to take.

Analysing the Brazilian society through the Hofstede Cultural Dimensions (Hofstede, 2015), we can understand that the score of the “Uncertainty Avoidance” dimension is high (79) meaning that usually the elements in this society present a heavy need for rules, strong processes and a detailed legal structure in order to organize their lives. However, the individual’s commitment to follow and obey these processes and laws is poor. Among the Brazilian society, according to this dimension, is all right to have bureaucracy, processes, laws and rules since they have the power to make the world a better place.

These intrinsic needs of the Brazilian society to have strong processes in order to structure life shall be also extrapolated to business and corporate governance need to embrace it.

As a healthy internal process, before the full funds authorization or the bid document approval (in case of a PPP model), companies shall submit the scope, costs and schedule baselines to an independent verification, reducing, therefore, the possibility of underestimated baselines, created during the development phase, to reach the real world. Confidentiality is a complicating factor in this independent verification activity because if a company is part of a public tendering for a specific PPP, the bid document is strictly confidential and contains the company strategy to be the winner in the bidding process. However, the confidentiality issue can be managed through contractual arrangements with the independent professionals that will verify the baselines. It is also recommended an independent verification of the field studies that need to be executed prior to the scope definition in order to avoid waste the scarce development time and budget.

Independent verifications, in summary, protect the company shareholders against the “Machiavelli factor” as defined by Flyvbjerg (2003), which is to “cook” the forecasts in order to get ventures started. It will also protect against general mistakes incurred by the development team

In order to the development team be able to better define the scope, cost and time baselines of an infrastructure construction project, the company can also implement the FEL methodology for the project development. This methodology is detailed in the Figure 28 below.

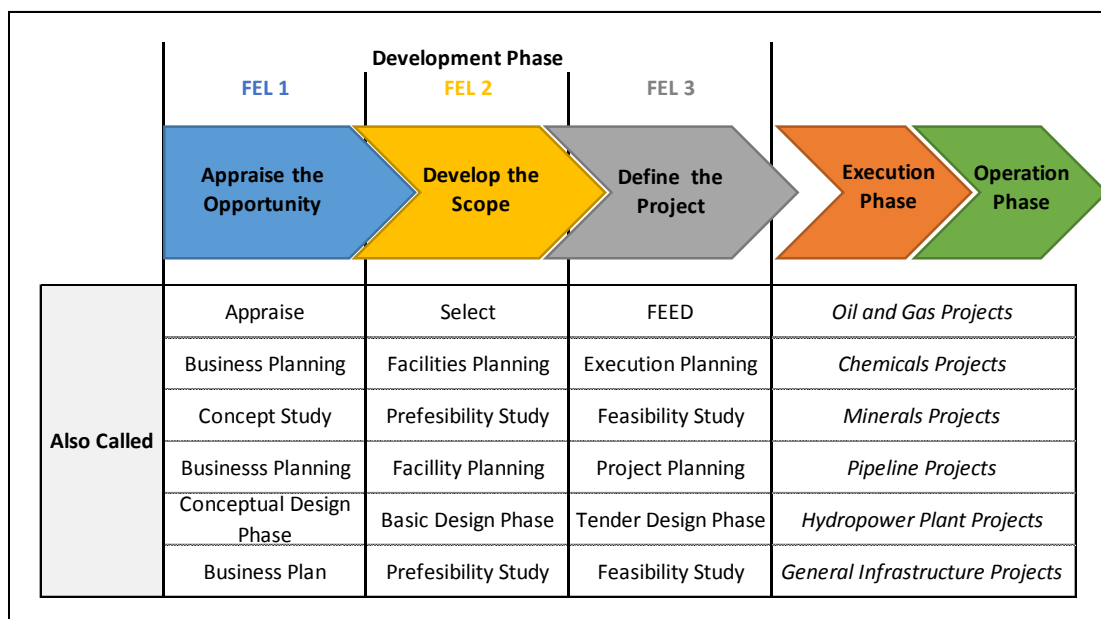


Figure 28 – Three Phased Front-End-Loading Methodology, based on Merrow (2011)

FEL stands for “Front End Loading” and is a stage-gated approach that authorizes the project development team to move ahead from one development phase into another development phase only if they manage to deliver what is requested for that specific gate. Merrow (2011) presents a three-staged FEL methodology in order to support and align the business development with the company needs. According to question 9 results, FEL 1, 2 and 3 are the ones responsible for project failure according to 83.05% of the respondents (Business Definition and Development Phase in Table 16 Figure 19 – Graph Question 9 - Phase that Most Contribute to Failure and Figure 19).

We call Front-end-loading the period prior to the sanction of the project (full funds authorization). FEL 1 is the first stage of the development, where the company will understand if the business case makes sense or not by sorting the basic feasibility of the business case. FEL 1 shall be used to winnow down the amount of possible projects to a manageable few to be exploited in FEL 2. The gate that will control the passage of the project from FEL 1 to FEL 2 is the least well managed gate according to Merrow (2011). Independent verification at this stage has a huge potential to save development costs and time in order to allow the company to only focus on projects that are consonant with its strategy and with the market reality.

In the beginning of the FEL 2 phase, a core technical team shall be formed in order to start the scope selection. The team will translate the company’s vision of FEL 1 into a real project with a proper scope definition. The level of the scope definition and deliverables in this phase should be aligned based on each type of project that are being developed. Independent verification on whether the scope developed until this stage and also cost and schedule baselines are aligned with external benchmark is a good practice and will help to avoid mistakes in the gate that will control the passage of the project from FEL 2 to FEL 3.

The third and last phase of the FEL methodology is the feasibility study itself, or FEL 3. In order to move from this phase of execution, a full funds authorization is required by the company shareholders, and this critical step shall be preceded by an advanced engineering development that will allow a detailed scope declaration, an accurate cost calculation and a precise schedule. These three baselines detailed and finalized in the FEL 3 phase, will form the “iron triangle” or the triple restriction were all next project phases will be based on.

In order to produce a well-engineered and well-detailed scope definition, all field studies shall be performed as a discussed previously. The attempt to cut

development costs and time during this phase, especially in the field studies, since they can represent between 2% to 3% of all project costs, is flirting with an economic collapse of the project. A budget cut in the scope of the site studies will be a sizeable amount of money saved, since the total investment of an infrastructure construction project is huge, but an incomplete site study can easily lead the project to huge cost overruns, slip in the execution schedule, leading the project to a complete fail.

In the next chapter (6.4) will be discussed the monetary incentives of the development team when dealing with infrastructure construction projects and how this could create a situation in which the development team and its managers will pursue different interests of those from the company shareholders.

Alignment of interest between the team that is developing the project (FEL 1, FEL 2 and FEL 3 phases) is essential for the project success. Due to the nature of the infrastructure construction projects, that will generate the revenues only in a long term, the development team can't be incentivized to pursue short term goals as the approval of the project to move from one phase into another. Their goals should be also long term related and completely aligned with the shareholder's goals. An interesting mechanism to align this type of interest is the employee stock options program that turns the employee "an owner" without diluting the ownership of the actual shareholders. It is crucial that the company, together with its HR department, be creative and develop incentives in a way to align the interests of people dealing with results that are measured only in a long term.

6.4 Ethical Implications

Ethical principles contribute with a clear framework in which a particular ethical implication could be analysed. Beauchamp & Childress (2001) defined five ethical principles that have been applied to several areas that are the following:

- (1) To respect the human being autonomy;
- (2) Don't harm others;
- (3) To benefit others;
- (4) To be fair;
- (5) To be loyal;

The findings of this research demonstrated that the majority of the infrastructure construction projects in Brazil are failing, and the poor performance of these projects is highly connected to the first phase of the project, the development phase, where the

scope, time and cost baselines are defined in order to demonstrate the project feasibility and get the investor's approval to authorize the funds to the execution.

In order to analyse the ethical implications of the findings, the profile of the respondents is as important as failure rate and its root causes. Approximately 87% of the respondents have more than 10 years of experience and 45% of the respondents occupy today strategic positions in the company (CEO, VP, Director or Project Director). This seniority among the respondents shows that despite of the huge failure rate found in their projects (62.15%) these respondents are the ones who have the biggest influence in how business are done.

The decision board or the decision maker, most of the times inside the investors' structure, are issuing approval of multimillion dollar investment plans based on unreliable information produced by the project team and approved by the management during the development phase.

The ethical implications of these findings in the business world are extensive and may breach each one of the five ethical principles defined by Beauchamp & Childress (2001) since the development team is incentivized to reach short term (one year) goals, like approvals for investment and business plan, and the infrastructure projects are able to generate results only in a long term. Flyvbjerg (2003) calls this act of deliberate "cook" the forecasts to get the ventures started, the "Machiavelli factor" and according to his studies, this situation happens very often in infrastructure projects like transport and logistics.

In order to widely understand the implications of the findings in the ethical principles, it is needed to detail how business leaders are monetary incentivized when dealing with infrastructure investments, usually in a PPP (Public Private Partnership) scheme, where the private company has frequently 20 to 30 years to explore certain asset before transferring it back to the sovereign state.

The monetary incentive of these business leaders is divided into a fix and a variable salary. Fixed salary is given by the market conditions, since it is paid monthly, independently on the company's profit or new businesses. The variable salary (e.g. Bonus), are usually paid annually depending on the goals that the employee has reached during the last year and this bonus, since it is "project based", could go from zero to a sizeable amount surpassing in many folds the annual fixed income, especially when dealing with infrastructure investments.

Infrastructure construction projects are long term projects by definition, especially the ones under a PPP agreement that were developed based on competitive public tendering. The investment breakeven is usually between 5 to 10 years from the start of the operations, so real infrastructure project performance, which will allow the company to pay healthy bonuses to its development team, shall be measured also in a long term. In summary, the monetary incentives of the team responsible for the business development activities up to full funds authorization must be attached to the project's long-term operational performance and not to its yearly milestones, like the business case approval, the approval of the feasibility study, full fund authorization, execution, etc. In this way, the conflict of interests between the development team and the company shareholders will be avoided thus reducing the potential breach of ethical principles.

Cultivating a system where the development team is incentivized to reach short term goals, without recognizing the long term project needs, is equal to develop a business trap for the shareholders. It is absolute imperative that professionals involved in the development of the infrastructure projects, that is, the ones responsible for the baselines that will guide the project approval (scope, time and cost), to receive the same incentives as the company shareholders in order to promote an alignment of interest.

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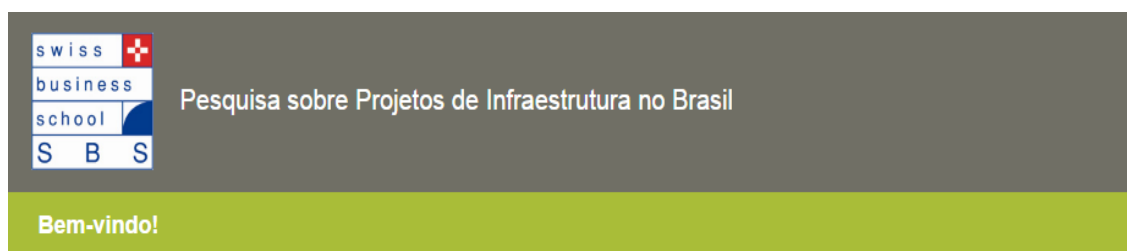
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APPENDIX A – ORIGINAL QUESTIONNAIRE (PT)

Original Online Questionnaire Page 1– Questionnaire Introduction



swiss
business
school
S B S

Pesquisa sobre Projetos de Infraestrutura no Brasil

Bem-vindo!

Obrigado por participar desta pesquisa que tem por foco os projetos de construção de infraestrutura no Brasil.


O volume de obras de infraestrutura no Brasil tem crescido substancialmente ao longo dos anos. Este fato atrai muita atenção no meio acadêmico e empresarial, principalmente no que se diz respeito as falhas em sua gestão e execução.

O questionário é objetivo e leva apenas 10 minutos do seu tempo. Porém é muito importante que suas respostas sejam dadas com bastante atenção aos quesitos.

Esta pesquisa é anônima e por isso tenha certeza de que todas as respostas individuais serão mantidas em sigilo.

Próximo

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 SurveyMonkey®

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Original Online Questionnaire Page 2 – Respondent's Profile

Experiência e Qualificação

1. Você tem experiência em obras de Infraestrutura no Brasil ?

- Sim Não

Exemplos de Obras de infraestrutura: Rodovias, portos, ferrovias, aeroportos, usinas de produção de energia, linhas de transmissão e distribuição, subestações, canais, sistemas de telefonia e dados, redes de água e esgoto, estações de tratamento, reservatórios, prédios públicos, entre outros.

2. Qual sua posição atual (ou última posição ocupada) ?

- Presidente, Vice Presidente ou Diretor
 Líder de Projeto(s)
 Gerente ou Líder de Equipe
 Profissional

3. Qual sua qualificação profissional ?

- Engenheiro
 Arquiteto
 Administrador
 Técnico ou Tecnólogo
 Outro

4. Qual sua qualificação acadêmica ?

- Doutor
 Mestre ou Especialista
 Nível Superior
 Técnico ou Tecnólogo

5. Quantos anos de experiência você tem na área de Engenharia e Construção ?

- 0 a 3 anos
 3 a 5 anos
 5 a 10 anos
 10 a 20 anos
 Mais de 20 anos

6. Para que tipo de empresa você mais trabalhou em sua carreira ?

- Empreiteira
 Investidor / Dono da Obra
 Projetista ou Consultor

Anterior

Próximo

Projetos de Infraestrutura - Falhas

7. Em quantos projetos de infraestrutura você já trabalhou no Brasil?

8. Baseado somente nestes projetos de infraestrutura que você participou no Brasil, complete as informações do quadro abaixo:

	Tipo de Projeto	Este projeto excedeu os custos em mais de 25% ?	Este projeto excedeu o prazo em mais de 25% ?	Este projeto teve sérios problemas operacionais até 2º ano de operação?
Projeto 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 4	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 5	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 5	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 6	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 7	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 8	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 9	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Projeto 10	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Favor responder para no mínimo 1 projeto que tenha experiência e no máximo para 10 projetos.

Anterior

Próximo

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Projetos de Infraestrutura - Causa Raiz

Responda as questões abaixo sabendo que **um projeto é considerado falho caso este não seja capaz de entregar os resultados exigidos pelo investidor.**

9. Na sua opinião, qual a fase que mais contribui para a falha de projetos de infraestrutura?

- Definição do Negócio
 Desenvolvimento
 Execução
 Operação

10. De acordo com sua experiência, a causa raiz mais frequente para a falha de projetos de infraestrutura é:

	Discordo Totalmente	Discordo	Neutro	Concordo	Concordo Totalmente
Falha na gestão do conhecimento	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falta de pagamento	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Não aceitação das comunidades locais	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falta de suporte do patrocinador do projeto (project sponsor)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falha na estimativa de custos	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falta de planejamento e controle apropriados	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estrutura organizacional do projeto inadequada	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falha ou inadequação na gestão de riscos	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falta de adequação estratégica do projeto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gestão / Liderança inadequada	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Força maior	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Equipe de projeto inexperiente	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falta de definição adequada de escopo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falta de comprometimento da equipe do projeto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falha na gestão de fornecedores e subcontratados	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Problemas ambientais fora do controle da empresa	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falha na gestão de suprimentos	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Comunicação falha ou inadequada	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Anterior

Próximo

Ativados pela



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Pesquisa sobre Projetos de Infraestrutura no Brasil

Considerações Finais

11. Na sua opinião, qual o percentual de falha em projetos de infraestrutura no Brasil ? (entre 0 e 100)

12. Na sua opinião, qual(is) a(s) causa(s) raiz(es) para falha em projetos de infraestrutura ?

Anterior

Concluído

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APPENDIX B – TRANSLATED QUESTIONNAIRE (EN)

Page 2 - Respondent's Profile

Q1	Do you have experience in infrastructure construction projects in Brazil ?	Yes	No			
Q2	What is your professional position ?	Director	Project Leader	Manager	Professional	Other
Q3	What is your professional qualification ?	Engineer	Architect	BBA	Technician	Other
Q4	What is your academic qualification ?	Doctor	Master	Bachelor	Technical	
Q5	How many years of experience in Engineering and Construction sector do you have ?	0-3	3-5	5-10	10-20	More than 20
Q6	What kind of company you most worked during your career?	Contractor	Investor/Project Owner	Designer / Consultant		

Page 3 - Threshold for Failure / Project Data

Q7 How many infrastructure construction projects have you worked during your career in Brazil ?

1 to 10 or more

Q8 Regarding only the Infrastructure Construction Projects that you have worked during your career in Brazil, please fill the table below:

PROJECT TABLE	Choose the Type of Infrastructure Project	Cost Overrun >25% ?	Slip in Execution Schedule >25% ?	Significant reduced operation into year 2 ?
Project 1	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 2	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 3	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 4	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 5	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 6	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 7	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 8	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 9	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N
Project 10	Logistics / Power / Telecomm / Water and Sewage / Other Type	Y/N	Y/N	Y/N

Page 4 - Root Causes of Failure (Likert Scale)

Q9 What is the phase that most contribute to infrastructure project failure ?

Business Definition Phase	Development Phase	Execution Phase	Operational Phase
---------------------------	-------------------	-----------------	-------------------

Q10 The main root causes for failure of infrastructure construction projects are:

C1 - Lack of project sponsor(s) support	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C2 - Lack of proper scope definition	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C3 - Lack of proper planning and control	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C4 - Lack of project strategic fit	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C5 - Lack of commitment of the project team	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C6 - Inadequate / lack of communication	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C7 - Improper management / leadership	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C8 - Inadequate / lack of project risk management	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C9 - Inadequate project organizational structure	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C10 - Inexperienced project team	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C11 - Lack of knowledge management	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C12 - Acts of good / Force Majure	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C13 - No acceptance of the local communities	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C14 - Uncontrolled environmental issues	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C15 - Failure in the cost estimation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C16 - Lack of payment	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C17 - Failure in the subcontractor management	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C18 - Lack of supply management	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Page 5 - Open Questions

Q11 In your opinion what is the failure rate of infrastructure construction projects in Brazil ?

0% to 100%

Q12 In your opinion what is the main root cause of these failures?

Open text