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Research Article

Assessing the Quality of Architectural Works in Underground Metro Stations in Egypt Via Six Sigma Methodology

Dalia Mohamed Massoud†*, Algendy Shaker Algendy‡ and Mohamed Ahmed Mahmoud†

†Architectural Department, Faculty of Engineering Al azher University, Cairo, Egypt
‡Associated Professor at Architectural Department, Faculty of Engineering Al azher University, Cairo, Egypt
†Doctor at Architectural Department, Faculty of Engineering Al azher University, Cairo, Egypt

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Abstract

The research is trying to find a new suitable strategy to assess the quality of Architectural works in the underground Metro Stations. Due to the important role which these stations play in crowded cities as Cairo. Applying six-sigma methodology as it based on rational analysis can achieve a fruitful success in construction field as it succeeded in the industry. This strategy not only can assess the quality level of Architectural works in the underground Metro Stations but also can discover its defects to ignore it in the upcoming stations. That will eliminate the unnecessary cost and will raise the values of the stations by achieving the high quality level. In addition, it will contribute in developing this great project.

Keywords: *Architecture works, underground metro stations, six sigma, rational analysis, quality level.*

1. Introduction

Despite of the bad economic conditions at the international and local levels, the Egyptian government is still supporting the national projects such as the underground metro stations, as this kind of projects have a great importance. It serves low incomes people and middle classes in the Egyptian society. It considered as the cheapest and fastest means of transportation; especially at rush hours. On the other hand, there are many quality tools that can be used in the construction industry but there is no clear measuring procedure based on rational analysis to assess the quality of Architectural works in underground Metro Stations in Egypt. Using the six sigma initiative leads to a suitable strategy that can assess the quality of Architectural works in the underground Metro Stations in Egypt. That came after studying the internal spaces and the architectural works needed in this kind of stations. The research problem is crystallized as in spite of a profusion the quality tools in the construction industry and the quality management but there is no clear measuring procedure based on rational analysis to assess the quality of Architectural works in underground Metro Stations in Egypt. This measuring procedure results will be a vital vehicle for the coming underground metro stations. The study aims to explore measuring procedure based on rational analysis via six sigma methodology to assess the quality of Architectural works in underground Metro Stations in Egypt.

*Corresponding author's ORCID ID: 0000-0003-1991-1499
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A. Main Objective: The main objective of the research is "to explore measuring procedure based on rational analysis via six sigma methodology to assess the quality of Architectural works in underground Metro Stations in Egypt.
B. Sub- Objectives:
   1) Understanding the perceptions of quality performance of the Architectural works in underground metro stations.
   2) How the six sigma is affecting in the process for measuring the quality level in the construction industry, especially in the underground metro stations.
   3) Determine the appeared latent defects to achieve the high quality requirements via six sigma methodology.

2. Materials and Methods

The paper mainly here represents the architecture in the underground station also definitions of its functional elements. (EDWARDS, Brian, 1997)

Definition of stations: They are the places where passengers travel and where traffic is frequent and speeding, and it is one of the most public functions in modern cities, a place where architecture and technology meet with a large number of users.

Entrances & Exits: These are the entry and exit points to and from the station and are increasingly important in the case of underground stations. Therefore, there should be ease, clarity and dimensions suitable for the size of the movement and full security for users.

Main Station Concourse: it is the main space to meet the passenger, the numbers of the passengers expected to use the station determines the ticket hall size, and signs are located to be an important guide for passenger's movement. The ticket office is always designed from a spacious room with a safe deposit box.
Platforms: the place where passengers take the train from or leave. This area is often separated by ticket barriers. Operating Conditions should be there and many items on the pavement such as signs, plates, station names, benches, waste boxes, fire extinguishers, and display screens for messages and media.
Operation Chambers: An area is not entered by the passengers and distributed within the station according to the requirements of operation and can be classified into three elements:
Components of the passenger service: These are the elements that serve the passengers.
so they are located in an average place in the ticket office treasury attached to (the police office - the director's office - first aid). Some stations may have shops and shopping mall.
Administrative elements: include changing rooms for workers, administrative rooms, assembly rooms and toilets.
Electromechanical Services: These include technical rooms, which are not allowed to enter this area such as Low Current Room, Lighting Power Station, and Air Handling Units.
The underground stations in Egypt are often distributed the functional elements on five main levels that according to national authority recommendations. These levels achieve all station's needs, the street level, ticket level intermediate level, platform level then the under platform level, in the flowing tables the study will show all the architectural spaces in each level.

Table 1 Architecture spaces in ticket level

Ticket Level	
Public Areas	Technical Areas
Station Masters Office	Fire Fighting Pump Room
Information room	Air Exhaust &Intake Gallery
Street Access	Lobby (SAS)
Police Officer's Room	Storage Room
Ticket Hall	Cleaning room
First Aid Room	Garbage Room
Receipt Room & Safe Deposit	Pump room
Elevator shaft	Changing room
Prayer Room	Chillers plat room
Ticket Office	Technical room
	Sef room
	Monitor room
	Fire Room
	Rectifire station

Table 2 Architecture spaces in intermediate levels

Intermediate level	
Public Areas	Technical Areas
Sanitary Facilities	Lighting Power Room
Intermediate Landing	Technical Room
	tunnel Ventilation Room
	Lobby (SAS)
	Sef room
	Storage Room
	Garbage Room
	escalators Maintenance room
	prayer room
	Free room
	operation corridor
	cable shaft
	secondary electrical cabinet
	maintenance staff room
	sanitary facilities
	battery room
	low current room
	operation corridor
	low voltage maintenance room

Table 3 Architecture spaces in platform levels

Platform Level	
Public Areas	Technical Areas
Platform	Cable shaft
Elevator shaft	Secondary Cabinet
Platform landing	Dewatering Access
	Switch Room Traction Current
	Under Platform Access
	Technical gallery

Table 4 Architecture spaces in under platform levels

Under Platform Level	
Public Areas	Technical Areas
No Public allowed	Foul Water Station Room
	Technical Gallery
	A/C Return Air Duct
	Electrical Gallery
	20 KV Cable Gallery
	Foul Water Pump Station

Material and finishing

The materials must appear safe and solid to passengers and staff. They must be durable and easy to clean and thus economical.

A-Floor Finishes

Floor finishes help define routes and the transition between the main functional zones of the station. Brick paving, non-slip stone finishes, terrazzo and textured ceramic surfaces could all be used to guide passengers at both perceptual and practical levels. Finishes that are robust and easy to clean are essential. It must be replaceable, fire resistant and textured so that those with partial sight can feel the edge of platforms or determine the destination route. (Hackelsberger, Christoph, 1997)

Table 5: flooring finishing materials in Cairo underground stations.

Flooring
Granite Flooring
Granite Edging
Unglazed Ceramic Tiles 20x20x0.8 cm
Anti-Dust Paint - Treatment no. 8
Unfinished R.C. Slab
Raised Floor - Laminated Finish
Anti-Acids Ceramic Tiles 20x20

B-Ceiling Finishes

Because of the need for hiding mechanical equipment, lighting fixtures, and acoustical needs almost all stations. Ceilings are constructed as suspended ceilings. Suspended ceilings should be as light colour and lightweight as possible. The construction of the suspended ceilings must be stable as to resist the pressure based from the movement of the trains. They should contain the lighting fixtures, mechanical equipment, and acoustical absorbent materials. (Hackelsberger, Christoph, 1997)

Table 6: ceiling finishing materials in Cairo underground stations

Ceiling
Cold Bent Enameled Steel Sheet
Vinyl Paint - Treatment no. 1
Vinyl Paint - Treatment no. 2
Lacquered Paint - Treatment no. 3
Microspores Paint - Treatment no.4
Acoustic Paint

C-Wall Finishes

An important requirement for wall design surfaces can be summarized as; ease of replacement, ease of cleaning, low absorption against graffiti, robustness, fire resistant, water and moisture resistance, resistance against all kinds of solvents and detergents. The surfaces must be easily cleanable without becoming worn or scratched, have a light reflection rate of 50% and this is generally achieved by exploiting light colors. Sharp edges of the walls should be rounded or protective panels should be placed at the edges. (Hackelsberger, Christoph, 1997)

Table 7: wall finishing materials in Cairo underground stations.

Walls
Trowel Cement Plaster
Glazed Ceramic Tiles (2.10 m height
Designed Ceramic Patterns
Designed Ceramic Patterns (Special)
Vinyl Paint - Treatment no. 1
Vinyl Paint - Treatment no. 2
Lacquered Paint - Treatment no. 3
Microspores Paint on Molded Wall Treat. no.4
Moulded Wall + Cement Plaster + Painting
Moulded Wall + Cement Plaster + Tiles
Unfinished R.C. or Blocks
Granite Tiles 2 cm Thick
Anti-Acids Ceramic Tiles (2.10 m height)
Moulded Wall + Ceramic Tiles on Removable Panels

3. The Assessment Methodology

The Six Sigma measuring system

Six Sigma methodology is providing the best solutions to many problems in industry field, business, or even in health sector. The research uses the flexibility for this methodology in Appling it in the architectural field. This methodology can achieve a great success as in the industry field. (Coskun A.R, Tamer C , Serteser M, 2011) Definitions: Sigma (σ), Greek letter that is the statistical representation of Standard Deviation, measures how far a given process deviates from perfection. The central idea behind Six Sigma is that if the number of “defects” can be measured in a process, then they can be eliminated by systematically figuring out how to get as close to "zero defects" as possible. The European Construction Institute (2004); defined Six Sigma as “A powerful management tool that assists companies to achieve breakthrough improvements in quality, eliminate defects, streamline operations, and thus dramatically improve profits. By redesigning and improving these processes, errors and waste are minimized leading to dramatic reductions in variability.” (Thawani, 2004)

A sigma quality level offers an indicator of how often defects are probable occur, where by higher sigma quality levels indicate a process that is less probable to create defects. A process with less variation is able to fit more standard deviations or sigma between the process center and the nearest specification limit than a process that is highly variable. (Low, P.S. , M.S. HUI, 2004)

Sigma quality level: Specification limits are the tolerances or performance ranges that customer's demand of the products or processes they are purchasing. Figure (3) illustrates specification limits as the two major vertical lines in the figure. LSL means the lower specification limit, USL means the upper specification limit and T means the target value. The sigma quality level (in short, sigma level) is the distance from the process mean (μ) to the closer specification limit. (Sung, H Park , 2003)

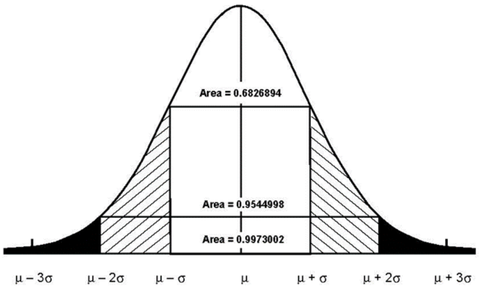

Figure 2: Normal distribution

In practice, we desire that the process mean to be kept at the target value. However, the process mean during one time period is usually different from that of another time period for various reasons. This means that the process mean constantly shifts around the target value. To address typical maximum shifts of the process mean, Motorola added the shift value ±1.5σ to the process mean. This shift of the mean is used when computing a process sigma level as shown in Figure 3. We note that a 6σ quality level corresponds to a 3.4ppm rate. This figure illustrates how sigma quality levels would equate to other defect rates and organization- all performances. Figure 3 shows the details of this relation- ship when the process mean is ±1.5σ shifted. (Sung, H Park , 2003)

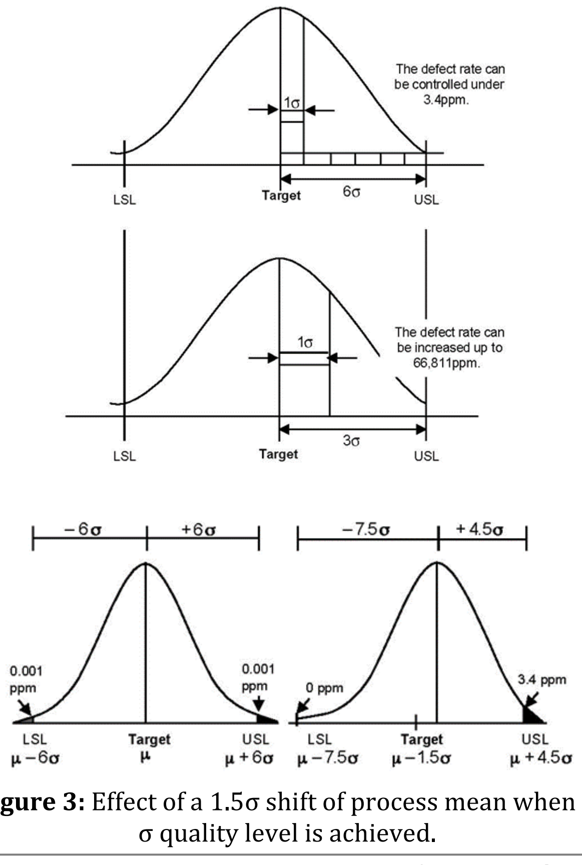

Figure 3: Effect of a 1.5σ shift of process mean when 6 σ quality level is achieved.

Table 8 Simplified Sigma conversion table

Yield = percentage of items without defects	Defects per million opportunities (DPMO(	Sigma level
30.9	690.000	1
69.2	308.000	2
93.3	66.800	3
99.4	6.210	4
99.98	320	5
99.9997	3.4	6

Six Sigma Tools, There are several models that can be used in the implementation of Six Sigma in projects. DMAIC, an integral part of the Six Sigma Quality Initiative, refers to a data-driven quality strategy for improving processes. DMAIC is an acronym for five interconnected phases: Define Measure, Analyze, Improve, and Control. (Amit, V. K. Sukhwani, 2016). **CONQUAS Assessment System**, to enhance and promote quality construction in Singapore, the Building and Construction Authority (BCA) introduced the Construction Quality Assessment System (CONQUAS) in 1989 to evaluate the quality performance of building contractors in the public sector. It is now regarded as the *de facto* quality yardstick for the construction industry in Singapore. CONQUAS was essentially developed to meet three objectives (Structural works, Architectural works, Mechanical and electrical works).the study will focus on the second objective as the research limitation. Architectural works deal mainly with the finishes and components. This is the part where the quality and standard of workmanship are most visible. (Low, P.S, KEE T.B. , A.A.A. LENG , 1999). The assessment covers: site inspection of internal finishes, roofs, external walls and external works at the completion stage of the building. Internal finishes include floors, internal walls, ceiling, doors, windows and components. Material and functional tests such as on window water tightness, wet area water-tightness test and adhesion of internal wall tiles. There is also in-process assessment on installation of waterproofing for internal wet areas. (Singapore Building Construction , 2005). In Six Sigma, measuring current performance is necessary before initiatives can be taken for Six Sigma improvement projects. (Ferng, J. , A.D.F. Price , 2005). To do so, the CONQUAS scores relating to internal finishes of a project completed by contractors were reviewed. The CONQUAS checklists relating to the completed project were then subject to Six Sigma. (Low, P.S, KEE T.B. , A.A.A. LENG , 1999)

4. Discussion and Results

Here the study will apply the six sigma methodology as a quality assessment of an underground metro station in Egypt. The pilot case study will be assessed by following six sigma quality tool (DAMC) steps and according to CONQUAS Quality Assessment System as the research referred before.

Define Phase: Haroun underground metro station located in line three in Cairo metro. The station consists of four underground floors .

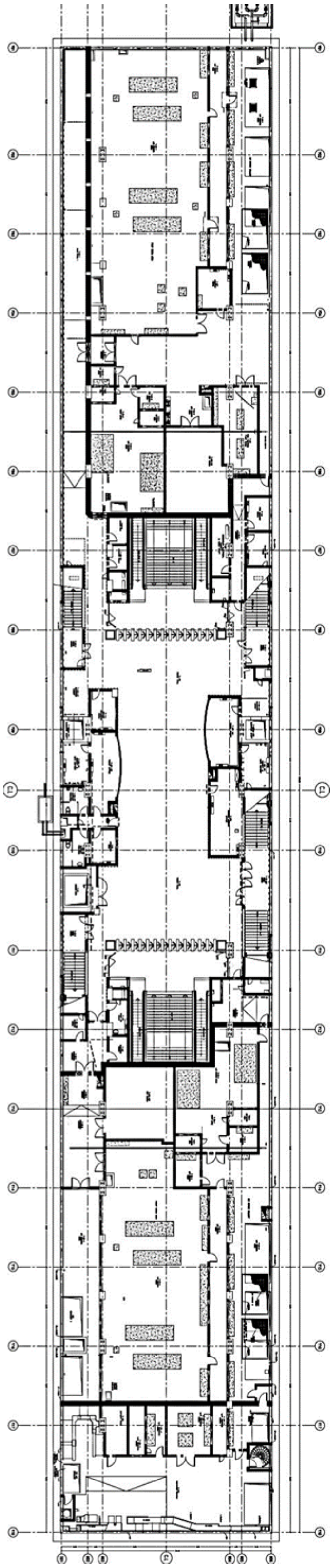

Figure 4 Platform Level Plan for Haroun station

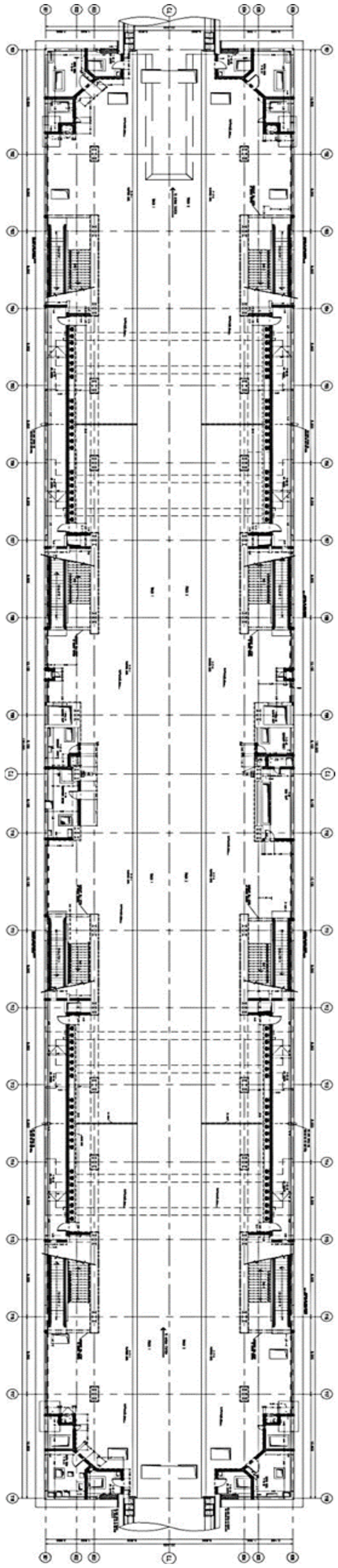

Figure 5 Ticket Level Plan for Haroun station

Measure phase: In this phase, the Quality Assessment System CONQUAS is used in measuring.

Table 9 : Defects grouping guide for assessment of internal finishes Singapore Building Construction Authority, 2005

Components	Defects Grouping	Defects description
Floor wall	Finishing	Stains, Painting / Coating Defects, Tonality, Patchy & Roughness
	Alignment & Evenness	Alignment, Unevenness, Squareness
	Crack & Damages	Crack, Chipping, Dent, Scratches
	Hollowness / Delamination	
	Jointing	Joints, Pointing
Ceiling	Finishing	Stains, Painting / Coating Defects, Patchy & Roughness
	Alignment & Evenness	
	Crack & Damages	Crack, Chipping, Dent, Scratches
	Roughness	
	Jointing	Joints, Pointing
Door window component M&E Fitting	Joints & Gap	Joints, Gap too big, Inconsistent, Improper Seal
	Alignment & Evenness	
	Material & Damages	Crack, Chipping, Dent, Scratches, Defects, Finishing, Tonality
	Functionality	Movement, Functionality, Cannot be Opened or closed properly.
	Accessories Defects	Missing items, Improper Fixing, Stains, Corrosion, Other damages

Analyze_phase: This important phase leads to obtain the main aim of the research, which is assessing the quality of the architecture works in the underground metro stations. The following figure shows the spaces in the left vertical side, on the other hand the assessing guides for Celling, floors, walls, doors and component as CONQUAS system. The insides squares filled according to the Inspection report. If the evaluated item does not meet the specified group satisfaction, in this case it will be considered as a defect. So "X" is indicated in the assessment, on the other hand "√" is indicated for the item which meets specified group satisfaction and the standards. (Low, P.S. , M.S. Hui, 2004)

DPMO = [No. of Defects ÷ (No. of Opportunities × No. of Units)] × 1,000,000.

This equation can be summarized as follow:

DPMO = [No. of Defects "X" on the Data Collection Sheet ÷ (No. of Opportunities or Defects × No. of Units)] × 1,000,000

The following equation is used to calculate the sigma indicator to assess the quality of the Architectural works for the underground metro stations (the pilot case study Haroun Station)

DPMO = 145/ (1330×1) ×1,000,000 = 109,002.56

On the sigma conversion shown in below figure, the equivalent sigma for the calculated DPMO of (109,002.56) is (2.7 σ), which means that percentage of items executed properly by the designer is only 88.5%.

Table 10 showing the measuring procedure in assessing the quality of the architecture works in the underground metro stations.

Location				Floors					Walls					Ceiling					Doors					Components				
Level	Area	Code	Space Tag	finishing	alignment & evenness	cracks & damages	hollowness	jointing	finishing	alignment & evenness	cracks & damages	hollowness	jointing	finishing	alignment & evenness	cracks & damages	hollowness	jointing	Joints and gaps	alignment and evenness	Materials and damages	functionality	accessories defects	Joints and gaps	alignment and evenness	Materials and damages	functionality	accessories defects
Ticket level	Public Areas	TP01	Station Masters Office	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		TP02	Information room	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√
		TP03	Street Access	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		TP04	Police Officer's Room	√	×	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	×	√	√
		TP05	Ticket Hall	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	×	√	√	√
		TP06	First Aid Room	√	√	√	√	×	×	√	√	√	√	√	×	√	√	√	√	√	×	√	√	√	√	√	√	√
		TP07	Receipt Room & Safe Deposit	×	√	√	√	√	√	×	√	√	√	√	×	√	√	√	√	√	×	√	√	√	√	√	×	√
		TP08	Elevator shaft	√	×	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√
		TP09	Prayer Room	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		TP10	Ticket Office	×	√	√	√	√	×	√	√	√	×	√	×	√	√	√	√	√	×	√	×	√	√	√	√	√
	Technical Areas	TT01	Fire Fighting Pump Room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		TT02	Air Exhaust &Intake Gallery	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√
		TT03	Lobby (SAS)	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		TT04	Storage Room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		TT05	Cleaning room	√	√	√	√	√	√	√	√	√	×	√	√	√	√	×	√	√	√	√	×	√	√	√	√	√
		TT06	Garbage Room	√	√	×	√	√	×	√	√	√	√	×	√	√	√	√	√	√	×	√	√	√	√	√	×	√
		TT07	Pump room	×	√	×	√	√	√	√	√	√	×	×	√	√	√	√	√	√	×	√	√	√	×	√	√	√
		TT08	Changing room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	×	√
		TT09	Chillers plat room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		TT10	Technical room	×	√	√	√	√	×	√	√	√	×	×	√	√	√	√	√	√	√	√	×	√	√	√	×	√

Location				Floors					Walls					Ceiling					Doors					Components				
Level	Area	Code	Space Tag	finishing	alignment & evenness	cracks & damages	hollowness	jointing	finishing	alignment & evenness	cracks & damages	hollowness	jointing	finishing	alignment & evenness	cracks & damages	hollowness	jointing	Joints and gaps	alignment and evenness	Materials and damages	functionality	accessories defects	Joints and gaps	alignment and evenness	Materials and damages	functionality	accessories defects
		TT11	Sef room	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	×	√	√	√	√	×	√	√
		TT12	Monitor room	√	√	×	√	√	×	√	√	√	√	×	√	√	√	√	√	√	√	√	×	√	√	√	√	√
		TT13	Fire Room	√	×	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	×	√	√
		TT14	Rectifire station	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	×	√	√	√	√	√	×	√	√
Intermediat level	Public Areas	IP01	Sanitary Facilities	√	√	×	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√
		IP02	Intermediate Landing	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√
	Technical Areas	IT01	Lighting Power Room	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT02	Technical Room	√	√	×	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT03	tunnel Ventilation Room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT04	Lobby (SAS)	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√
		IT05	Sef room	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√
		IT06	Storage Room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT07	Garbage Room	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT08	esclators Maintenance room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT09	prayer room	√	×	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT10	Free room	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√
		IT11	operation corridor	√	√	×	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√
		IT12	cable shaft	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT13	secondary electrical cabint	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT14	maintnance staff room	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	×	√	√	√	√	√	√	√
		IT15	sanitary facilites	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT16	bettery room	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT17	low current room	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		IT18	operation corridor	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	×	√	√	√	√	√	√	√
		IT19	low voltage maintnace room	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Platform level	Public Areas	PP01	Platform	×	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	×	√
		PP02	Elevator shaft	×	√	√	√	√	×	√	√	√	√	×	√	√	√	√	√	√	×	√	√	√	√	×	√	√
		PP03	Platform landing	√	×	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	×	√
	Technical Areas	PT01	Cable shaft	×	√	√	√	√	×	√	√	√	√	×	√	√	√	√	√	√	×	√	√	√	√	×	√	√
		PT02	Secondary Cabinet	×	√	√	√	√	√	×		√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	×	√
		PT03	Dewatering Access	√	√	×	√	√	×	√	√	√	√	×	√	√	√	√	√	√	×	√	√	√	√	√	√	×
		PT04	Switch Room Traction Current	√	√	√	√	×	√	×	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	×	√	√
		PT05	Under Platform Access	√	×	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√	×	√	√	√	√	×	√	√
		PT06	Technical gallery	√	√	√	√	×	×	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√
Under Platform level	Technical Areas	UT01	Foul Water Station Room	√	×	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	×	√	√
		UT02	Technical Gallery	√	√	√	×	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	×	√	√	√	×	√
		UT03	A/C Return Air Duct	√	√	√	×	√	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		UT04	Electrical Gallery	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√	√	√	√
		UT05	20 KV Cable Gallery	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		UT06	Foul Water Pump Station	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
No. of Defects				40					32					18					33					22				
No. of opportunities				255					263					277					262					273				
Total No. of Defects				145																								
Total No. of opportunities				1330																								

Table11 Sigma conversation

Yield	DPMO	Sigma	Yield	DPMO	Sigma	Yield	DPMO	Sigma
6.6%	**934.000**	**0**	**69.2%**	**308.000**	**2**	**99.4%**	**6.210**	**4**
8.0%	920.000	0.1	72.6%	274.000	2.1	99.5%	4.660	4.1
10.0%	900.000	0.2	75.8%	242.000	2.2	99.7%	3.460	4.2
12.0%	880.000	0.3	78.8%	212.000	2.3	99.75%	2.550	4.3
14.0%	860.000	0.4	81.6%	184.000	2.4	99.81%	1.860	4.4
16.0%	840.000	0.5	84.2%	158.000	2.5	99.87%	1.350	4.5
19.0%	810.000	0.6	86.5%	135.000	2.6	99.90	960	4.6
22.0%	780.000	0.7	88.5%	115.000	2.7	99.93%	680	4.7
25.0%	750.000	0.8	90.3%	96.800	2.8	99.95%	480	4.8
28.0%	720.000	0.9	91.9%	80.800	2.9	99.97%	330	4.9
31.0%	**690.000**	**1**	**93.3%**	**66.800**	**3**	**99.977%**	**230**	**5**
35.0%	650.000	1.1	94.5%	54.800	3.1	99.985%	150	5.1
39.0%	610.000	1.2	95.5%	44.600	3.2	99.990%	100	5.2
43.0%	570.000	1.3	96.4%	35.900	3.3	99.993%	70	5.3
46.0%	540.000	1.4	97.1%	28.700	3.4	99.996%	40	5.4
50.0%	500.000	1.5	97.7%	22.700	3.5	99.997%	30	5.5
54.0%	460.000	1.6	98.2%	17.800	3.6	99.9980%	20	5.6
58.0%	420.000	1.7	98.6%	13.900	3.7	99.9990%	20	5.6
61.8%	382.000	1.8	98.9%	10.700	3.8	99.9992%	5	5.8
65.6%	344.000	1.9	99.2%	8.190	3.9	99.9995%	5	5.9
						99.99966%	**3.4**	**6**

Improve phase: This phase aims to create ideas to solve and prevent the problems. These problems clearly appeared in the previous phase (analysis phase) as the sigma is measured. The different defects, which showed in celling, flooring, walls or even in the component can be solved easily. The contractor can get more specified and well training workers. Should Follow and abide the authority Rules and instructions.

Control phase: This vital process based on the previous one. Hence after determine the defects which appeared in the executed works, it was necessary to control and monitoring to safe and protect the project from reappearing this defects again, as If mistakes are made during the construction stages, they cannot be rectified easily, that cause loss of excessive amount of money and time. Therefore, a systematic approach is required, from the very beginning; to achieve good standards On the other hand the owner (authority) can control this by choosing high classification contractors for this job.

Conclusions

The researcher regarding underground metro station Architectural work observes many problems. In order to overcome this problem, the research presents an appropriate solution, by using the six sigma methodology in assessing such this stations.

1) The Six Sigma evaluation outcomes results are a fair assessment system.
2) Using Six sigma performance indicators at the project assessment process guarantee the national projects in more scientific rational analysis way that achieve the end-project goals as end- user need.
3) Encouragement to study and publish the Six Sigma methodology in all fields, especially engineering field, and that will change the level of implementation and develops the performance clearly.
4) Spreading awareness among the bodies that finance national projects to activate this modern technology in measuring the quality of their projects.
5) Urging the designer from the start to use modern systems for evaluate projects at the design stage.
6) For improvement, poor workmanship problem could be removed by training of workers.
7) Teams could be constituted, skilled and trained staff could train workers, show them how to construct buildings correctly and at high quality.

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