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Domes Restoration Process Technique

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Abstract: A general objective of structural design that aims to provide protection is unrestricted free space. The potential structure, expense of materials, and difficulty of building limit the necessity for such a facility. This objective can be effectively achieved using space structure and more specifically, the dome structure system. The dome's ability to be formed so that its members are below the pressure axis is a benefit. Metal alloys like steel and aluminum, which have a relatively good strength-to-weight ratio, are the most popular building materials for long-span domes. This technique tries to locate appropriate tools and supplies for the task of recoating dome panels that have coating issues with the current technique. The court complex served as the site for this study, which involved an experiment representative from the applicator and specialist as well as the contractor and client, who carried out 4 experiments with various tools and materials to determine their suitability for the work process. Based on the study's findings, it was discovered that one of the materials and pieces of equipment that had been tested had produced a result that could be agreed upon by all parties, specifically the use of grinder points that were suitable for the client-required criteria. It is also because it saves time taken.

Keywords: Dome Structure System, Coating, Recoating

1. Introduction

The dome is considered as one of the most important architectural elements in the architecture of mosques, and Islamic architecture in general where the use of domes in Islamic architecture started from the Umayyad period in Jerusalem in 691 AD. Since ancient times, the architect was able to link architecture to his beliefs and applied that to serve his intellectual trends by developing the design concept for himself, most notably, the shifts and changes that have occurred in the forms of the domes since the dome is characterized by its deep memory as it documents the symbolism in Islamic architecture over time, and the Muslim architect considers it as an important historical record, but it

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needs to be studied and analyzed to keep up with the current architecture and its developments. The coating technique is one of the methods in dome restoration. Spray coating is a technique used for repairing geodesic domes. It involves spraying a coating over the surface of the dome to seal gaps and prevent leaks. Spray coating is a technique used for repairing geodesic dome tank roofs. The coating can cure quickly after being applied directly over the seal while proving stronger than tape and more chemically resistant to acids, fuels, etc. Spray coating is also an ideal solution for geodesic dome repairs, tank containment repairs, waterproofing, and other industrial coating repairs. In this project, the upgrading of the court complex has been awarded to EUSB. from 14 September 2020 until 11 September 2022 for a period of 24 months covering Architectural Work, Works Structure Repair, Provisional Sum, and Prime Cost. Based on the term of reference, the main scope layer is such as painting the exterior facade of the building, repairing structural and wall cracks, changing the waterproofing layer on flat roofs and domes, upgrading and repairing mechanical and electrical systems as well as other related works.

1.1 Background of Study

Domes are an ideal structural system for covering long-span distances without requiring any support obstructions. Some of the main usages for domes include sports stadiums, convention centers, exhibition halls, and assembly places. The dome provides wide column-free spaces which means the dome can enclose a maximum amount of space while requiring a minimum amount of surface area. Restoration of the dome coating is necessary to ensure the dome is protected from further damage and to extend its lifespan. The restoration process may involve removing the old coating and applying a new one to protect the dome from corrosion, weathering, and other factors that can cause damage (Tracy, 2017). Dome coating may need restoration due to various reasons, including:

i. Corrosion because exposure to rain, snow, sleet, and sun can cause damage to the exterior of the dome, especially if it is made of cast iron
ii. Weathering and ultraviolet rays can cause fiberglass to deteriorate over time
iii. Over time, the coating on the dome may deteriorate, and lose its strength, and durability, which can affect the performance of the dome.
iv. Damage to the dome caused by natural disasters, accidents, or other factors may require restoration of the coating

The main objective of the re-coating dome panel is to avoid leakage to the floor below. Furthermore, waterproofing systems keep moisture from intruding into the facility and protect the structural contents from water infiltration that can cause structural damage to the concrete or corrosion to the embedded steel. Therefore, this results in the ability to cover an extremely large area while requiring minimum material and thus usually proves to be an economical structural system. Re-coating is to clean the site area from oil, grease, and dust using a water jet before applying the waterproofing system. The surface shall be prepared by using appropriate tools to remove the old protective coating. Recoating dome panels is one of the works that need to be implemented in this project. The existing problem for this project is to include identifying and marking the defective areas and making good any damage including interior and exterior finishes for the main dome. There are several surface dust, watermarks, and stain contaminants in the dome area. Dome with existing pre-formed rubber strip. Existing rubber strips along the joints peeled off exposing capping fasteners to rust screws, loosen plates, fungi growth, and raining water seepage.

Before re-coating work is carried out, several steps of work need to be done starting with surface preparation, repair works, polyurea coating works and lastly painting works surface preparation needs

to be done by removing old painting coating until bare metal for preparation of polyurea coating. The grand entrance on Mass Ave was completed in 1939. In 2019, an 80-year check-up seemed warranted, and a study initiated by the facilities department found deterioration of the building exterior and waterproofing. Restoration of the little dome began in July 2020, it includes masonry, metal flashing, and skylight repairs as well as replacement of the upper roof of building 7.

To fill in the appropriate troubleshooting while removing the old painting coating on the existing dome panels. Surface cleaning by hand tools such as scrapers, sanders, and wire brushes is relatively ineffective in removing mill scale or adherent rust. Hand tool cleaning removes only loosely adhering paint, rust, and mill scale. It is slow and produces a burnished rather than a textured surface that permits only limited coating adhesion, it will not remove surface contaminants and soluble salts. Thus, it is used mostly for spot cleaning. This is because the thickness of the dome panel is only 2mm thick. It has a fairly large impact if the main powers rub quite hard. Regarding the unsuitable method proposed by our client, we would like to cater to this issue by using a more suitable method and equipment for dome panels that is more effective and time-consuming. The restoration process involves several phases, including exterior, interior, and rotunda, and requires the use of various repair methods to correct defects that occurred during the dome's construction (Alan, 2016).

2. Methodology

Traditional restoration techniques, however, retain the major limitations of Dahlstrom's model, which applies geometric and kinematic rules in two-dimensional domains (Al-Fahmi et al., 2016) Methodology required based on the project. it will determine the appropriate materials and equipment for the dome restoration process. The main project is to upgrade the existing dome due to the condition of the dome which is Surface dust, watermarks, and stain contaminants in the Dome area. The project will be conducted through analysis, interview, and experiment. The document that will be involved is a project report and will be monitored by the client and applicator, for the selection methods statement that will be used.

2.1 Research Design

The two stages of the technical study process are as follows:

i. Data collection from documents on several construction projects
ii. Experiment with appropriate equipment.

There are various research methodologies, but the qualitative and quantitative ones are frequently and extensively employed in the build environment industry for analysis reasons. To determine the appropriate equipment to be used to remove the old protective coating and to reduce the time taken for the restoration of domes at the court complex by taking preventative measures, a quantitative research technique was used in this study. It is useful to evaluate and interpret the case studies' quantitative data more efficiently by employing tables, graphs, and figures. The research employs a quantitative methodology and is based on secondary information that was gathered from earlier works to conduct further analysis. In this method, an interview was conducted with the engineer and contractor due to the material selection for the work process.

The goal of employing a case study is to gain a deep understanding of the data and investigate it for further research so that a comparison of their commonalities and the distinctiveness of each project can be made. It's vital to understand the selection of appropriate equipment because there are various reasons why they can use the equipment or material, and different regions might have different causes. Their data analysis helps to provide a clearer understanding of the causes for the delay as well as

appropriate recommendations for future projects and other scenarios. Additionally, this helps to pinpoint potential countermeasures that could be taken to lessen the effects of a delay and provide information for future instances.

2.2 Research Procedure

This research follows a mixed method of quantitative and qualitative approaches. Qualitative data collection was provided through the provision of a comment section in an otherwise closed-ended questionnaire where the respondents gave additional information to add depth to responses given quantitatively.

2.3 Research Instrument

The researcher used a variety of information sources for this study, including literature reviews and videos during the experiment. Data analysis brings order, structure, and meaning to the mass of collected data. It is a messy, ambiguous, time-consuming, creative, and fascinating process. It does not proceed linearly; it needs to be neat.

3. Results and Discussion

After data collection and analysis are carried out, each piece of information and findings collected is discussed to obtain conclusions and recommendations to be used in the dome restoration process for the court complex. The discussion is based on the findings of the study from chapter four, which analyses the data collected to ensure that the materials and equipment for recoating dome panel works are suitable. The results obtained from the experiments carried out, namely sanding, high-pressure water jetting and rotary grinder are used to make recommendations. The results of the experiments carried out are important in analyzing the efficiency and effectiveness of recoating dome panels. Conclusions were made based on the discussion. Furthermore, the engineers, applicators, and anyone involved in this project will also cooperate to ensure that the materials and equipment selected are suitable according to the effectiveness of the dome panel.

Figure 1: Standard Profile Surface Preparation

Table 1: Method of Experiment

No	Experiment	Effectiveness
1	Sanding	Sa 3 (White)
2	High-pressure water jetting	Sa 1 (Sweep)
3	Rotary grinder	Sa 3 (White)

3.1 Results

In this study, an experiment was used as a method design tool to collect and analyse data. The following is the format of the experiment to identify the most suitable equipment for removing the old protective coating of domes.

3.1.1 Experiment 1 (Sanding Test)

According to the results of the Newman-Keuls tests, there is a substantial difference between the Ra and Rz values of panels that were sanded at feeding rates of 40m/min. rougher surfaces were significantly produced by significantly faster feeding. This might be because the panels spend a longer time in the sanding machine at slower feed rates. As a result, polishing the surfaces and removing dust and other residues will be more effective at slow feeding speeds. Table 2 shows that the thickness of the test panels was determined to be 2mm for feeding speeds of 40 m/min respectively. The amount of material eliminated rose as the feeding speed dropped. When boards are fed into the sanding machine too quickly, difficulties with barrel-shaped board thickness, belts running off the machine, and sanding chatter result. These flaws make the panels' surface more uneven. It was discovered that the surface roughness was significantly influenced by the feed power of the sander's heads. The test panels' roughness was enhanced by raising the energy value. This might be caused by an increase in sand pressure on the surface brought on by an increase in energy.

Table 2: Newman-Keuls Test Results

Factor/Average Roughness	$R_{a\ (\mu m)}$	$R_{z\ \mu}$	$T^{2\ mm}$
Feeding Speed: 40m/min	6.91	52.55	2.00
Energy: 50kW	10.55	69.23	16.05
Grits: 40-60-80-120	9.88	66.40	16.67

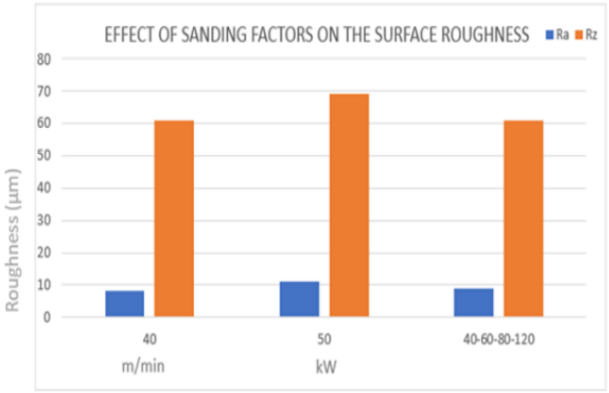

Figure 2: Effect of Sanding Factor

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The sanding machine vibrates because of the low power output. The growing surface roughness linked to the use of low machine energy may be caused by this vibration. For higher energy levels and pressures, there is more material removed from surfaces. This conclusion is supported by the test panels' thickness values. Table 2 demonstrates that as machine energy increased, the thickness of the panels reduced. The impact of various sanding parameters on the particleboard surface roughness is depicted in Figure 2.

3.1.2 Experiment 2 (High-Pressure Water Jetting)

Unfouled panels painted with antifouling paint that contains copper were used for the tests. The panels were used to evaluate each set of jet conditions' cleaning capacity. By methodically jetting on the painted panels, potential paint damage was evaluated. A simulated fouling was used to conduct screening tests of several jet configurations because there weren't enough foul panels available for testing. Steel plates with various adhesives were studied based on prior work by Conn. Many epoxies

turned out to be too brittle. The desired removing properties of a rubberized under coating were discovered, and they outperformed tests with fouled panels.

At a translation velocity of 0.6 m/s, Figure 3 provides an example of data demonstrating the impact of standoff and pressure on paint removal. Even at 1500 Psi, the actual damage to the paint is minimal, leaving less than 25 microns of removal at a standoff of more than 4 cm. No significant paint loss at 1500 PSI pressure; at 2500 PSI, less than 13 microns removed at 1.3 cm standoff. Additionally, this picture shows how deadlocks are decreased because of, for instance, local surface protrusions not impacting the paint.

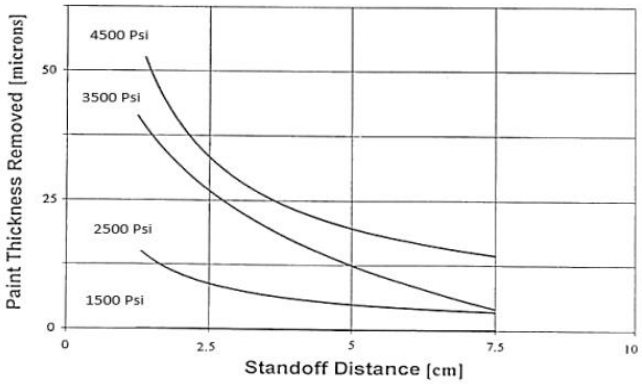

Figure 3: Curve fit data Showing the influence of the standoff and pressure on paint removal at a translation velocity of 0.6m/s

3.1.3 Experiment 3 (Rotary Grinder)

A flap disc's (Figure 4) ability to remove material effectively depends heavily on its design. To effectively remove the material being worked on, the abrasive grain must be attached to the fabric in such a way that it holds to it for as long as possible. However, once that section of abrasive grain is depleted, it falls away cleanly, revealing the fresh new abrasive material on the underlying flap to begin working on the surface at hand. With the usage of the product, the abrasive grain on the outer edge of the wheel's backing will begin to wear away thanks to the design of flap discs. The wheel has the property of offering a more consistent finish and uniform cut rate than other types of traditional abrasives since this results in new grain being exposed.

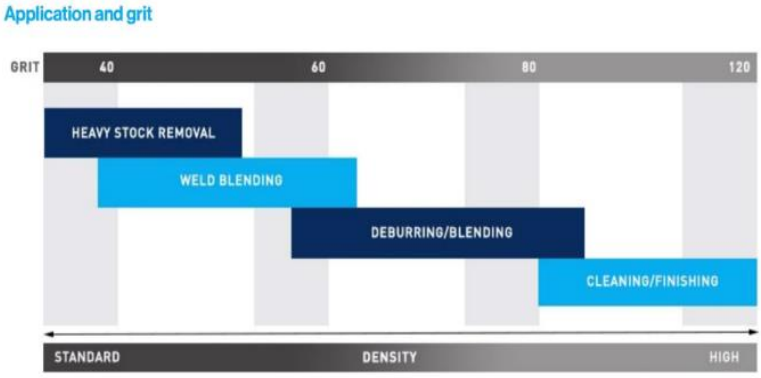

Figure 4: Flap Disc 5 grit ranging between 24 grit and 120 grit

The efficiency of the various types of disc grit employed is displayed in Table 3. The efficiency of the trial dome panel varies depending on the grit disc employed. The fact that the dome panel is 2mm thick indicates that the 60-grit disc is appropriate because it has little impact on the dome panel's surface. Figure 5 displays the efficiency of all grit disc types tested, ranging from 40 to 120 grit.

Table 3: Results of type of disc grinder

Type of Disc Grinder	Results
40 Grit	Aggressive grinding and weld removal
60 Grit	Medium grinding and finishing are required in one step
80 Grit	Light grinding with more emphasis on finishing
120 Grit	Extra fine surface finishing

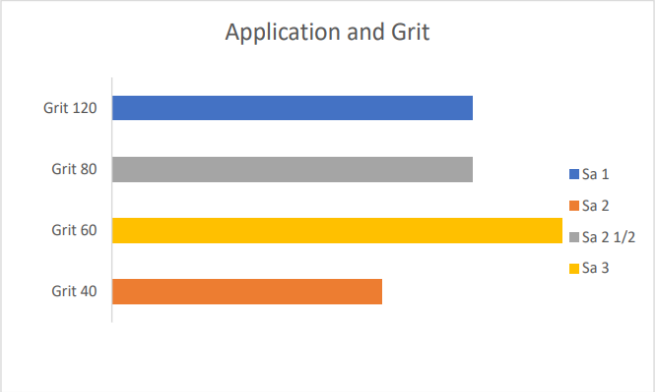

Figure 5: Ranging between 40 grits to 120 grits

3.2 Discussion

The objective of this study is to identify the restoration process method with the time taken, to identify the appropriate equipment used to remove the old protective coating and to identify materials that are suitable for removing old protective domes. With the results of the analysis obtained, it can be said that all three objectives in this study have been achieved.

3.2.1 The Restoration Process Method with Time Taken

The main objective of this study is to prevent leakage to the floor below. Furthermore, the waterproofing system is to keep moisture from intruding into the facility and to dampen structural contents from water infiltration that can cause structural damage to concrete or corrosion to embedded steel. Painting and preparation of the surface should be done by removing the old paint coating until the metal is empty for the preparation of the polyurea coating.

Researchers used equipment including sanding instruments, high-pressure water jets, and rotary grinders to obtain data on the dome's restoration process. The researcher believes it will be difficult to fully achieve this first objective due to limited equipment and the difficulty of finding free time when it is practical to collect data at the site location. According to (Mohammad, 2019) Restoration durations are typically estimated based on the availability of various prime mover types, sizes, and numbers. In these estimates, it is assumed that load can be picked up 88 as soon as generation becomes available, and the time required for switching operation to energize transformers, energize lines, and pickup loads

are much less than the time required to make the generation available. Restoration planning entails the development of a strategy that meets the primary goals of minimizing the duration of an outage and maximizing customer service. Such a strategy typically should include several distinct levels of restoration for various system conditions. Each level in turn should consist of several interdependent activities. The entire strategy then should be broken down into some logical order to provide a discipline that reduces the risk of overlooking any essential operation. In the comparison of three devices, it was found that there was a difference in the data before and after the experiment. This appears to be because the equipment used to re-coat the dome panels is suitably efficient. Although some experiments are carried out that do not get proper results, the objective is achieved.

3.2.2 The Appropriate Equipment Used to Remove Old Protective Coating

The second objective of this study is to identify the appropriate equipment to use to remove the old protective coating. After data collection and analysis through experiments conducted at the KMKL construction site about the effectiveness and efficiency of the equipment used, it was found that the equipment from Experiment 1 and Experiment 2 had several issues. For example, the equipment used takes too long and there is no trace of removing the old protective coating according to the analysis results.

Loose rust, loose mill scale, and deteriorated coatings can be removed by the effective use of hand and power tools (Protective Coatings,2021). Brush-Off Grade Blasting (SSPC-SP 7) cleans to the same requirements and may be used as an alternative to scraping and wire brushing. Before scraping and wire brushing, remove grease, oil, salt, chemical dust, and other contaminants by Chemical Cleaning. Removal of heavy rust scale, light mill scale, or previous coatings over extensive areas usually requires Commercial Grade Blast Cleaning (SSPC-SP 6) or Industrial Blast Cleaning (SSPC-SP-14). Chip, scrape, or wire brush rusted surfaces thoroughly to produce a tightly adhered surface that is clean and free of foreign matter to assure good coating adhesion. Care must be taken with power tools to avoid polishing a metal surface or abrading it too deeply. Tightly adhered coatings that are very hard or glossy should be sanded to remove gloss and slightly roughen the surface. This will contribute to the maximum adhesion of the new coating. Examine existing coatings carefully for signs of rust beneath the coating. If present, remove coatings in these areas.

3.2.3 Material That is Suitable for Remove Old Protective Coating

The third objective of this study is to identify suitable materials for removing the old protective dome. Researchers can see favorable results on dome panels by comparing data through experiments. There is one of the experiments that was done that showed good results, also according to the specifications from the client. Also, the researchers concluded that there was a pretty good difference in the dome panel after the upgrade. Based on the experiment done by the client and the applicator, they gave a satisfactory response after the dome panel was carried out. This experiment was carried out before the recoating of the dome panels was carried out on site. This is to ensure that the equipment used in the experiment has a good impact before it is done on the real dome panel. Regarding the third objective, it can be stated that it is achieved by experiments that are done after the upgrade work is done. The recoating of the dome panels is carried out at the construction site after the parties involved have witnessed the results of the experiments carried out. In addition, it is also seen in terms of time that affects.

4. Conclusion

The study was conducted to achieve the objectives of the study time taken objectives, suitable equipment, and suitable materials to remove the old protective coating. The researcher also collected data before and after the experiment was conducted to compare the results of both measure data. This was done to observe the experiments carried out to achieve the desired specifications for recoating dome panels. It could be concluded that the study has successfully achieved its objective.

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