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Importance of Raw Material Testing at Construction Site

Authored by Chetan Paul

EXECUTIVE SUMMARY

This paper is written to highlight the importance of testing of raw materials at construction sites. In any industry, raw materials play a vital role in obtaining a good finished product. Likewise, in the construction industry, raw material testing is essential to ensure the desired results and mitigate the risk of future deformities. However, it is frequently observed that the procedure for raw material testing has been skipped or, in majority of cases, is not being performed in accordance with the codal provisions due to budgetary constraints, stringent timelines, reluctance from project stakeholders, and inadequate knowledge of the testing process. This may have an adverse effect on the overall design life of project. Therefore, it is very essential to implement the testing of raw material by which the quality issues can be easily identified at the preliminary stages to avoid rework, cost associated and to ensure durability of the infrastructure of a project.

The article provides a high-level overview of the importance of raw material testing during the construction phase and its implementation techniques with the help of site quality assurance. Scrutinizing approved sources of raw material and proper implementation of testing will help to achieve the desired quality of the project and sustain its design life.

INTRODUCTION

Solar power plants are one of the most important source of renewable energy, and their construction requires the use of several raw materials. Solar PV projects are considered to be of less complexity as compared to conventional projects. Therefore, the process of essential raw material testing at solar power projects are often ignored which actually impact the overall design life of the plant and consequently impact the OPEX of the plant during the operation and maintenance phase.

Raw material testing is an important step during the construction phase of solar power projects. This testing ensures that the materials used in the construction of the project are of high quality and suitable for their intended purpose. By testing the raw materials, engineers and contractors can identify any potential defects that may impact the durability of structure.

As we all know the quality of construction is mainly depending upon the standard of the material. In order to maintain the construction quality in Solar industry, it is necessary to carry out in-depth research on construction engineering materials.

Necessity of Raw Material Testing

Raw material testing helps to identify any potential weaknesses in the materials that could lead to future deformities, this could easily be prevented after the performing the tests and analyzing the results based on standard industry practices and relevant IS Standard.

The material testing gives you an understanding of how the finished product will behave whilst in use. Furthermore, it also helps in understanding the strength or pressure that a sample can endure, thereby knowing its exact point of failure.

Material testing reduces the risk of costly implications in future, which can be devastating for company reputation. Hence, the probable key issues along with the mitigation measure will be highlighted in the subsequent paragraphs to enlighten the importance of raw material testing.

The following are the major construction material which requires field testing to correlate the results with respect to the approved specification based on the relevant IS standards:

1. Cement
2. Fine and Coarse Aggregate
3. Bricks
4. Reinforcement Bars
5. Concrete

The following are the tests to be conducted to assess the acceptance quality of raw material:

Field test for Cement:

- Color test of cement: Uniform, grey color with a light greenish shade.

- Presence of lumps: The cement should be free from any hard lumps.
- Smoothness test: The cement should feel smooth when touched or rubbed in between fingers. If it is felt rough, it indicates adulteration with sand.
- Feel test of cement: If hand is inserted in a bag of cement or heap of cement, it should feel cool and not warm.
- Float test: If a small quantity of cement is thrown in a bucket of water, the particles should float for some time before it sinks.
- Date of packing: Generally, the cement should be used before 90 days from the date of manufacturing.
- Review of MTC (Manufacturer test certificate) for every lot.

Field test for Sand:

- Source Identification: The sand used for concrete shall be from the same approved source used for preparing the design mix.
- Test for clay: Field test can be performed by rubbing a small amount of sand between finger tips. If clay is left on finger tips, it indicates the existence of clay in a considerable amount. The tested sample shall be free from deleterious materials such as clay and similar materials that impact the durability of the concrete.
- Test for silt: This test is performed to identify the silt content. If excess quantity of silt (>8%) in sand is observed, then the test sample shall be rejected. Excess quantity of silt reduces the bonding capacity of raw materials and affects the strength and durability of concrete.
- Moisture Content: Moisture present in fine aggregate affects the water-cement ratio in the concrete mix. Therefore, it is important to perform the moisture content test of coarse and fine aggregate to check the moisture content and moisture correction to be performed to control the water cement ratio, as higher water content in the concrete reduces the compressive strength tremendously.
- Sieve Analysis for gradation: Sieve Analysis of sand is performed to check the gradation of sand particles. Sand particle distribution in sand volume is important for good quality concrete and mortar. In this test, the sand sample is passed through a series of IS sieve sizes ordered from bigger to smaller sizes at the bottom.

Field Test for Coarse Aggregate

- Sieve Analysis for gradation: The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design.
- Water absorption: Water absorption gives an idea on the internal structure of aggregate. Aggregates having more absorption are more porous in nature and are generally considered unsuitable, unless found to be acceptable based on strength, impact and hardness tests. The maximum water absorption of coarse aggregates, as per IS 383-1970, should not exceed 4%.
- Elongation and Flakiness index: Elongation and flakiness index are important in determining the strength and durability of a material, and their proper determination is

essential for quality assurance.

Field test for the Steel Bar:

- Approved make and country of origin to be verified for the sample of steel bars at site.
- The diameter of the bar shall be checked with Vernier calliper and shall not be uneven in size.
- The rebar should be able to bend and rebend without breakage.
- Standard length of bar shall be physically checked as 12m by standard steel measuring tape.
- Visually the Steel bar shall be inspected and free from rust.
- Rolling Margin : Rolling margin is the difference between the theoretical and actual weight of steel bar. It can be ascertained with the help of calibrated weighing machine.

Field test for the Bricks:

- Nail scratch test: A good brick should resist scratches against sharp things. So, for this test a sharp tool or finger nail is used to make scratch on brick. If there is no scratch impression on brick then it is said to be hard brick.
- Shape and size: Shape and size is one of the factor to identify the class of brick. (A, B, C class)
- Soundness test: When two bricks are struck against each other, it should produce a metallic sound and brick should not break. Then it is said to be of good quality brick.
- Water Absorption test: The water absorption test is performed to identity the percentage of water absorbed by the bricks after immersing the bricks in the water for 24 hours. Ideally water absorption of bricks less than 20% should be considered for the construction of important structure.
- Efflorescence: Efflorescence is a deposit of water soluble salts formed on the surface of concrete and brick masonry due to the movement of water through pores. When water gets evaporated, efflorescence is formed as the dissolved salts gets deposited on the surface.
- Compressive strength: Compressive strength determines the load carrying capacity of a material. Minimum compressive strength of 1st class brick is 105 kg/cm^2. 2nd class brick is 75 kg/cm^2 which are generally used for the construction purposes.

Field test for the Concrete:

- Trial Mix: The trial mix is to be performed at site before commencement of actual execution to determine the actual strength of concrete.
- Compressive Strength: It helps in determining whether correct mix proportions of various mix proportions of various materials were used to get the desired strength.
- Workability by Slump Cone: Any concrete mixture needs to be sufficiently workable to be properly placed and compacted with the available procedures to fill the forms completely and surround the reinforcement and other embedded items.

- Temperature: High concrete temperatures increase the rate of hydration, thermal stresses, the tendency for drying shrinkage cracking, and permeability and decrease long-term concrete strengths and durability as a result of cracking. The ideal temperature for pouring concrete is between 10˚C (50˚F) and 32˚C (≈90˚F)

These images from project sites illustrate improper testing of raw material like cement, sand and aggregate may lead to production of poor quality of concrete which does not comply as per the approved design mix.

Figure (A)

Figure (B)

In Figure (A), shear slump was noted, as the concrete is in inclined plane. It indicates lack of cohesion in the concrete mix. Whereas, Figure (B) shows the collapse slump which indicates the mix is too wet i.e very high workability thus reducing the overall designed strength of concrete.

There are many factors involved in the deviation of concrete slump with respect to the design mix e.g. change of source of coarse and fine aggregate, shape and size of aggregate, moisture content of sand, improper grading of coarse and fine aggregate, improper quantity of admixture and water cement ratio etc.

The use of cohesion-less concrete in any structure can lead to several problems, including cracking of the concrete due to a lack of strength and stability and poor strength of the bonds between the concrete and the reinforcement. Furthermore, this type of concrete is more prone to deterioration due to its lower quality and lack of cohesion. When it comes to structural safety, cohesion less concrete may lead to an increased risk of failure due to its low structural integrity.

The consequence of using the faulty concrete could be evidenced in Figure(C) and (D), Over a period of time the binding property of concrete have deteriorated due to improper cohesion of mix concrete and as a result the reinforcement was exposed to the atmosphere. This further lead to corrosion of reinforcement due to oxidation process which had eventually impacted the sustainability of the structure.

Figure (C)

Figure (D)

In the second case, it can be observed that the testing for efflorescence of bricks has been ignored. As a result, deposition of salts on the walls can be noticed as illustrated in Figure(E) and (F), which eventually caused the finished paint and plaster to peel off. This may further lead to disintegration of the structure and develop further defects like seepage, cracks etc.

Figure (E)

Figure (F)

The above issue had a significant cost impact, which has been identified at a later stage during the O&M phase. With the low tariff and high competitiveness in the market, the budget for carrying out the O&M activities is very limited. Issues illustrated above, place an additional burden on the developer. SgurrEnergy has witnessed the issues during the several due diligence of the operational projects, and in most cases have concluded the ignorance of conducting the raw material testing during the quality control process at site.

To mitigate the above concerns, Figure (G) illustrates the process for accepting the appropriate raw material which is further used for the construction of foundations, roads, drainage etc.

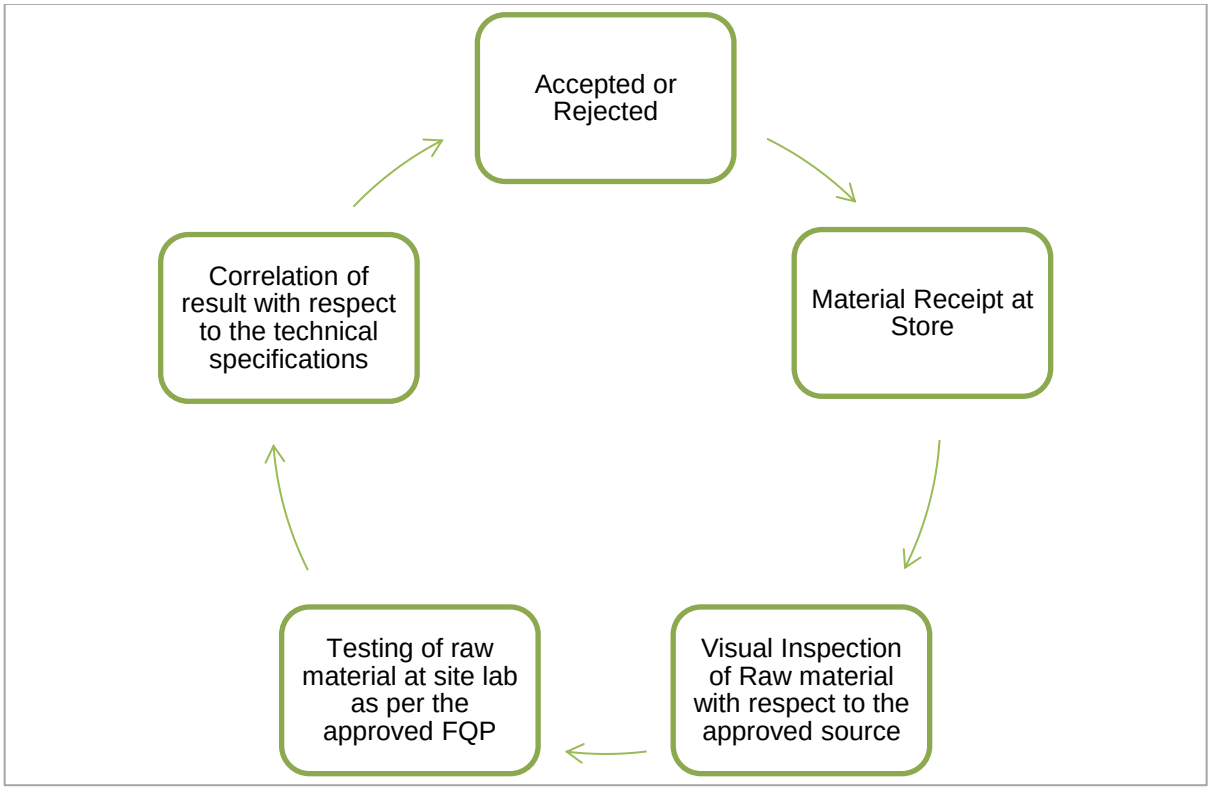

Figure (G): Process for Acceptance criteria of Raw Material

Appointing an independent third party Project Management Consulting team whose dedicated quality engineers ensure the testing of raw materials at construction site during the project phases to confirm the implementation while complying with the requirements of industry standards is the most feasible way to ensure the raw materials quality.

Engineers would primarily ensure and educate contractors to follow the specifications recommended as per the relevant IS codes. Proper implementation of raw material testing will identify grass root deformities at the beginning stage, which may develop into serious defects in the future and impact the plant's life. The implementation of the whole process would benefit the developer in setting up an ideal plant by avoiding the cost overruns and time extension involved in reworks within the optimum budget and timeline.

CONCLUSION

In conclusion, the importance of raw material testing at construction of solar power plants cannot be underestimated. It is essential to ensure that the raw materials used in the construction phase are of the highest quality and free from any impurities or contaminants which may impact the design life of solar power plant. By testing the raw materials used in the construction process, any potential problems can be quickly identified and addressed, thereby avoiding costly and time-consuming repairs down the line.

In the absence of an independent third party project management consulting(PMC) team on site, the rectification or capex cost required to extend the useful life may go up to approximately 1% of the project value, which would be a huge amount and would affect the return period. To mitigate the above issues, it is essential for the solar industry to appoint PMC team to ensure the completion of project within stipulated timeline, budget, and, most importantly maintain highest standards in terms of Quality and safety in order to attain and maintain a high level of project construction at a cost of less than 0.2% of the overall project value. In the long run, investing on a PMC agency will result in lower operational costs, increased ROI, and a better quality project that can sustain its design life.