JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Case Study on Design of High-Grade Self Compacting Concrete Using Conventional Placing System

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Abstract

Concrete is a mixture of cement, sand, gravel and water that dries hard and strong and is used as a material for building. Concrete has to be heavily vibrated for flow into terribly intricate forms that have plenty of reinforcing bars. Thus, to beat these defects, the self-compacting concrete is used. Self-compacting concrete is a flowing concrete mixture that's ready to consolidate under its own weight. The self-compacting concrete flows simply at appropriate speed into formwork without blocking through the reinforcement without being heavily vibrated. Concrete placement is a very important method within the construction that determines the success of the structure and its life. The concrete is transported, poured, vibrated, matured into the form and then removed and cured. Each of those phases should follow techniques that may come under smart construction practice. Before any concrete is placed, the complete placing program consisting of equipment, layout, planned procedures is planned and no concrete is placed till formwork is inspected and located appropriate for placement. Equipment for conveying concrete should be of such size and design as to ensure a practically continuous flow of concrete during depositing without segregation of materials considering the scale of the job and placement location. Concrete is transported by a variety of different methods starting from wheelbarrows, dumpers and ready-mix trucks to skips and pumps, and it's clearly desirable to place the concrete directly into the position but this is not always possible always. As an example, it'll rarely be practical to discharge from a dumper or ready-mix truck directly into the top of a column or wall. Thus, this paper summarizes the case study based on placing of self-compacting concrete using typical placing system by crane bucket.

Keywords: Self-Compacting Concrete, Micro Silica, Super plasticizer, Workability, Compressive strength.

Introduction

Self-compacting concrete (SCC) is a concrete mix which has a low yield stress, high deformability, good segregation resistance and moderate viscosity necessary to ensure uniform suspension of solid particles during transportation, placement without external compaction until the concrete sets.[4] SCC is an extremely fluid mix.[3] It flows very easily within the formwork. It does not require vibration or tamping after pouring. Once poured, SCC is usually similar to conventional concrete in terms of its setting, curing time and strength. SCC gains its fluid properties from an unusually high proportion of fine aggregate, such as sand, combined with super plasticizers. SCC was conceptualized in 1986 by Prof. Okamura at Ouchi University, Japan at a time when skilled labor was in limited supply, causing difficulties in concrete-related industries.[5] The first generation of SCC used in North America was characterized by the use of higher binding materials along with high dosages of concrete admixtures in order to enhance the flowability and stability.[5] Such high- performance SCC had been used mostly in repair works and for casting concrete in congested areas. SCC is used for casting heavily reinforced sections, places wherever there will be no access to vibrators for compaction and in complicated shapes of formwork which can preferably be not possible to cast, giving a far superior surface than standard concrete.[7] The comparatively high price of material utilized in such concrete continues to hinder its widespread use in varied segments of the construction industry, including commercial construction, but the productivity economics take over in achieving favorable performance advantages and works out to be economical in pre-cast industry.[8] The incorporation of powder, together with supplementary cementitious materials and filler, can increase the volume of the paste, therefore enhancing deformability, and might also increase the cohesiveness of the paste and stability of the concrete.[6]

Theory

Concrete is a vital material and plays a major role in the quality of buildings or structures. Apart from concrete mix being correctly designed, batched, mixed and transported, it is also important to place concrete correctly. The placing of self-compacting concrete is an essential operation because it largely determines the success of a structure and its durability. Therefore, concrete placement must be carried out in systematic and efficient way to give the best results.
Two of the most commonly used concrete placing techniques in high rise structures are discussed below:
i. Crane bucket
ii. Pumps and pipelines

Crane bucket: A tower crane bucket is one of the methods of transporting concrete above the ground level. Crane is used for transporting concrete horizontally and vertically and also in an inclined way. It is generally practiced in medium and large construction projects. In this method, transportation of concrete is fast and the placement of concrete takes place at the specific point. Crane consists of buckets for containing and placing concrete in its specified location.

Pumps and Pipelines: Pumping of concrete is more reliable method of transportation and placing of concrete. Its working starts with the suction mechanism which sucks the concrete inside the pipe. A piston is provided for the suction and delivery of concrete. It is essential to choose the correct diameter and wall thickness of the pipeline to match the pump and requirements of placing rate. High pumping pressure is required for long horizontal distance. In this case, large diameter pipe could be an ideal choice to account for less resistance to flow. If it is needed to pump concrete to height, due to the gravity and the weight of concrete in the line, a smallest possible diameter of pipelines should be used.

Comparision

Table 01: Comparison between mostly adopted concrete placing technique for slender members in high rise structures

Name of technique	Cost	Placement Ease	Wastage
Crane Bucket	It is a cost-effective method as it does not requires more number of equipment's & labors	It is easy to place the SCC in the slender members with this technique	The concrete gets less wasted by using this placement method
Pumps & Pipelines	It is not a cost-effective method as it requires more number of equipment's & labors	It is not a desirable method to place a concrete in slender members as it becomes cumbersome	The concrete gets more wasted by using this placement method

Literature Review

Chris I. Goodier (2003)[1] outlines a brief history of SCC from its origins in Japan to the development of the material throughout Europe.

Dinesh. A et. al (2017)[2] deals with the self- compacting concrete where the cement is partially replaced with fly-ash and silica fume.

Krishna Murthy.N et. al (2012)[3] presented an experimental procedure for the design of self-compacting concrete mixes.

N R Gaywala and D B Raijiwala (2011)[4] has discussed the progress of the research on different harden properties of Self Compacting Concrete using the Ordinary Portland Cement "UltraTech" made and low-calcium fly ash from Birla Glass, Kosamba, Gujarat, as binder materials in making the concrete mixes along with other ingredients locally available in Gujarat.

Ouchi et. al (2003)[5] covered the applications of SCC in Japan and Europe. It discusses the potential for structural applications in the U.S. and the needs for research and development to make SCC technology available to the bridge engineers.

Payal Painuly and Itika Uniyal (2016)[6] has reviewed the development of Self Compacting Concrete (SCC). The workability properties of SCC such as filling ability, passing ability and segregation resistance are evaluated using workability tests such as slump flow, V-funnel and L-Box tests.

Rajdip Paul and Debashis Bhattacharya (2015)[7] has discussed the mechanical properties of SCC in comparison to conventional concrete are discussed.

Udit A Chavda and Dr. K. B. Parikh (2018)[8] presented the literature reviews related to behaviour of self-compacted concrete.

Case Study

The client involved was Ruparel Realty. The work was undertaken in two projects namely Ruparel Ariana and Jewels located in Sewri, Mumbai. The contracting agency was Umang enterprises and RMC manufacturer was Navdeep construction RMC, Sion. The projects consisted total number of floors in Ariana and Jewels were 73 and 54 respectively. Grade of concrete was M80 (SCC) and concreting at 40th and 15th level of Ariana and Jewels respectively by conventional placing system using bucket was carried out.

Materials

1. Cement- Ambuja OPC 53 grade of cement was used.
2. Fly ash- Jaycee Class F Fly ash wasused.
3. Micro Silica- Micro Silica was obtainedfrom China.
4. Coarse Aggregate- Coarse Aggregates of size 10mm was used for this researchwork. It was sourced from a quarry in Turbe in Mumbai,India.
5. Fine aggregate-Fine Aggregatesused for this research work was crushed sand (VSI). It was sourced from a quarry in Turbe in Mumbai, India.
6. Water- Water was obtained from a boring. It conformed to IS 456-2000 requirements.
7. Admixture- High PCE Sikaviscocrete5210NSwasbeing used.

Mix design

In this, Experimental Work Department of Environment (DOE) Method of mix design was used for manufacturing concrete of grade M80.

Table 02: Mix proportion of SCC (M80)

Cement	OPC -500 kg/m^3
Flyash	170 kg/m^3
Micro silica	50 kg/m^3
Water	160 kg/m^3
Crushed sand	625 kg/m^3
Coarse aggregate 1	950 kg/m^3
A/C ratio	2.19

W/C ratio	0.22
Admixture	0.6 to 0.8 %

rocedure of placing the self-compacting concrete using conventional bucket technique:

The placing of self-compacting concrete is an essential operation because it largely determines the success of a structure and its durability. In this particular case study, placing technique by crane bucket system is discussed below in detail.


Fig 1a: Pouring of Concrete


Fig 1b: Transportation of Bucket


Fig 1c: Placing of Concrete

Figure.1 shows the transfer ofself-compactingconcrete(SCC) from transit mixerintobucket. Thetransit mixer is kept in rotation at a constant rpm during the transfer of concreteinto the bucket.

Figure. 2 shows the transportationof bucket containing SCC with the help of crane at the desired level of the structure where SCC has to bepoured.

Figure. 3 shows placing of concrete in the member at desired location. The bucket is positioned at the middle of the member where theconcreting is to be done to ensure the even flow of SCC in member in order to avoid the air voids. The bottom valve of bucket is opened gradually thereby releasing the SCC into the member.

Test Results

Flow table test Initial flow : 700 mm
Flow at the point of pouring after 2 hours : 400 mm without bleeding and segregation. Compressive strength @ 28 days : 83.12 MPa

Summary

It is summarized from the above case study that crane bucket placing system is found to be suitable for concreting of slender member such as columns, shear walls, etc. where the volume of the concrete is around 10 m^3 due to following factors:

- Cost effective
- Ease of placement
- Less wastage of concrete

Conclusion

As per the site experience and observations, pumping placing technique is generally used for casting of slabs since the quantity is more than 75 m^3. On the other hand, starters for columns, shear walls and lift walls are casted as per the requirement and the overall quantity for such work does not exceed more than 6 m^3. In addition to that the total concrete quantity for casting of the entire columns, shear walls and lift walls is less than 40 m^3 and hence concrete pump is uneconomical in this case as the wastage in the pipeline at higher floors proves to be expensive.

Hence, it can be concluded that placing the self-compacting concrete in slender members like columns and shear walls is found to be more economical using conventional placing method using bucket technique over other concrete placing technique.

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