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Specification of Raft Foundations for Tower Buildings

Prescriptive vs Performance Based Specification

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Features

A lot of tower buildings have been built in Arabian Gulf region during the last decade, the raft foundation forms a primary structure element of such buildings, Thickness of some of them are up to 3 m or more, thousands of concrete cubic meters may poured in such elements, for instance more than 11700 m^3 poured in a single raft foundation in Riyadh in 2010 by Saudi Readymix Concrete Company.

Project Specifications usually specify a max temperature of 70C and a differential temperature of 20C. Raft foundations usually specified with a high strength concrete "HSC" (50, 60, 70 MPa) at 28 days at the same time.

Using 65%-70% of GGBFS or 35% - 40% of Class F Fly Ash to meet the heat of hydration "HOH" requirement of 3m thickness or more makes meeting the requirement of achieving HSC of 60 or 70 Mpa at 28 days challengeable and most often a complex scenario.

The max temperature of 70C generally specified to avoid the negative effect of delayed Ettringite formation "DEF" occurs in some concretes. When DEF occurs, cement paste expands and cracks the concrete with detrimental results. Studies shows that concrete containing cementitious materials may have a reduced risk of DEF, Concrete containing 20% slag and 20% Fly Ash were found to suppress the formation of expansive DEF. ACI 301-10 states "The maximum temperature in concrete after placement shall not exceed 70C, but in notes to specifier it states "Concrete that contains supplementary cementitious materials may have a reduced risk of DEF and may justify internal temperature above 70C".

The simple approach of specifying the difference temperature not to exceed 20C is based on studies with a series of small-unreinforced concrete dams constructed in England more than 50 years ago. ACI 301-10 mentioned that "the maximum temperature difference between center and surface of placement shall not exceed 20°C", but in notes to specifier it states "A higher difference limit may be acceptable depending on concrete properties, placement dimensions, and reinforcement configuration. The temperature difference limit for a specific concrete mixture and placement conditions can be determined through numerical simulations and comparing calculated thermally-induced strain with tensile strain of concrete."

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Thermal cracking occurs when thermal stress exceeds concrete tensile strength, in case of HSC temperature difference limit of 20°C can be conservative especially when low thermal expansion aggregate such as Limestone or Granite used. Some researchers have suggested 25°C temperature difference limit will be appropriate for concrete with Granite Aggregate and 31C for concrete with Limestone Aggregate.

Specifying HSC at 28 days for a raft foundation is very conservative, the full loading of raft foundation may not occur before months “sometimes years”, Specifying HSC at 56 days or even at 90 days will be more appropriate.

Technology available facilitates simulation tools which can be used for the simulation of HOH to a very good accuracy level considering HOH profile of a concrete sample, weather conditions, placement condition, curing and isolation plan. Some of them provide a cracking and/or strength development profile, which can be used to determine the acceptable difference temperature limit. Quadrel IQ-drum technology is just an example.

Prescriptive specification which simplify the limits of max temperature as 70°C and temperature difference limit as 20°C or specifying HSC at 28 days in all raft foundations creates a complex situation and a real challenge to mix designers with a rarely quality benefits. In many cases such specifications are just a “copy and paste” of international specifications.

Performance based specification which takes in account concrete properties, structure condition and technology available allows mix designer to optimize mixes that meet both requirements of HOH and HSC, it facilitates the ability of getting a sustainable, cost effective and quality concrete solution.

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Research & Development Center (R&D)

Saudi Readymix is proud to announce the inauguration of its Research and Development Center. The R&D Center was partially opened in October 2016. Saudi Readymix R&D Center is the first private R&D and innovation center in the field of concrete technology in Saudi Arabia.

The center is two-story building and it is located in Dammam 2nd industrial city. 1st floor accommodates the laboratories and the second floor has the offices, meeting room and training room.

The center is operated by highly skilled staff and equipped with state-of-the art equipment.

The center has two main divisions: concrete and blocks division and cement, mortar and supplementary cementitious materials (SCM) division.

The R&D Center is responsible for conducting research and development on current and new products and raw materials and works constantly to develop and innovate new materials and processes. In addition, the Center addresses current and future challenges to come up with innovative solutions and transferring new technologies to the local industry.

Moreover, the Center serves as a central lab and is responsible for qualifying and approving SCM, chemical admixtures and special additives and materials to be used in the production of concrete and other concrete products e.g. blocks and mortar.

Through partnering with local, regional and international universities and institutes the Center will conduct advanced research and testing for internal needs and external clients.

Knowledge and results will be disseminated through seminars, published papers and articles.

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