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Round Determinate Panel testing

Nowadays, reliable and consistent methods for the characterization of fibre reinforced concrete and fibre reinforced shotcrete are commonly used in practice. Round Determinate Panels (RDP) are tested by imposing a central point load at a controlled rate of displacement and measuring resistance as a function of deformation.

The construction industry has taken considerable strides forwards over the last two decades. The development of new technology in materials sciences is progressing rapidly. Advanced building design and construction technology are allowing structural designers to push concrete to its limits in order to meet design aspirations. The world stage is seeing new concrete buildings with a higher aspect ratio.

The impressive tall thin shapes currently rising around most of all in the Middle East are driving new advances which will benefit construction around the world. High Strength Concrete and High Performance Concrete are gaining wide acceptance in today's construction industry, and are well positioned for increasing usage in the future. They will continue to make important contributions to the enhanced quality and efficiency in the construction of infrastructure and our communities in the next century.

Flexural test on Fibre Reinforced Concrete (FRC) beam specimens

The testing of flexure on FRC beam specimens is nowadays commonly applied. The test evaluates the flexural performance of toughness parameters derived from FRC in terms of area under the load deflection curve obtained by testing a simple beam under 3 or 4 point loading. The toughness gives an indication of the energy absorption capability of the specimen and its magnitude depends directly on the geometrical characteristics of the test specimen and the loading system. The flexural test can be represented by the load versus deflection curve as per ASTM C1018/ C1609 or load versus Crack Mouth Open Displacement (CMOD) as per EN 14651. In the first case the area under the load-displacement curve is calculated for multiple values of the displacement at the first crack, in the second case the residual flexural tensile strength is evaluated for specified values of crack opening.

Fig. 1: Model 50-C1601/FR 300kN high stiffness frame, the test configuration conforming to ASTM C1550

Central loading test on FRC slab specimens

Recent research studies [7] relating to tests on beams as well as round panels with the same mechanical properties and fibre content have revealed that the high scatter generally present in beam tests is caused by the small geometry and fracture area involved in the tests, which less represents the actual structural behaviour. Real structures are characterized by a high degree of redundancy in which stress redistribution may occur, generating larger fracture areas and lower dispersion. Specimens with larger fracture areas are needed in order to obtain a more realistic value from FRC material tests suggesting the use of larger beams or different specimens such as slabs in which stress redistribution may also occur.

With the central loading test on square or round slab specimens the energy absorption is evaluated through the load-deflection curve. Generally, both with square and round slab specimens the deflection is approximately 1/20 of the free vertical clearance in order to generate a wide crack path, which involves great deformation energy.

With the flexural test on square slabs (e.g. EN 14488-5, UNI 10834) the specimen supported on a rigid square frame is loaded through a steel square block at a specified rate of displacement.

A round slab specimen, called Round Determinate Panel (RDP) has been proposed by ASTM C1550 and the method is actually increasingly being used. The specimen is supported on three symmetrically steel ball pivots therefore statically determinate, the crack pattern is predictable and the post-cracking material properties can be better determined. The consistency of the failure mode that arises through the use of three symmetrically arranged support pivots results in low within-batch variability in the energy absorbed by a set of panels, which are loaded up to a specified central deflection [5].

The performance of specimens is quantified in terms of the energy absorbed in the post crack range between the onset of loading and selected values of central deflection. The load is applied via a hydraulic jack fitted with a spherical joint at a prescribed rate of displacement.
The use of round panels also eliminates the sawing that is required to prepare shotcrete beam specimens. The nominal dimensions of the panel are 75 mm in thickness and 800 mm in diameter. Thickness has been shown to strongly influence panel performance in this test, while variations in diameter have been shown to exert a minor influence on performance [5]. The heavy mass of a hardened round slab specimen does not represent a problem on most construction sites because handling equipment is generally available to move such bulky objects. Considering the superior reliability of round determinate panels and the consequent reduction in the number of specimens required per sample, the overall cost of quality assurance testing process is significantly lower when based on round determinate panels compared to beams. Formwork for round determinate panels typically consists of a round plywood base to which a sheet steel strip is nailed, producing a dish. The width of the steel strip is chosen to produce a final depth of 75mm inside the dish. Timber can be fastened to the base of the form to facilitate easier handling of the hardened specimen, which generally weighs about 90 kg. Once the form is full, the surface must be screened to produce a flat specimen of uniform thickness, which is a fundamental point towards achieving low variability. The performance can in fact be strongly dependent on the final thickness and uniformity of the specimen.

Fig. 2: Model 50-C9842 ADVANTEST 9. Servo-hydraulic automatic control unit

Round Determinate Panel testing machine

The required RDP testing machine is servo-hydraulic, incorporating an electronic feedback loop that uses the measured deflection of either the specimen or the loading actuator to control the motion of the actuator to produce a monotonically controlled and constant rate of increase of deflection of the specimen without the intervention of an operator. The flow of oil must be accurately controlled reacting immediately to small variations, which ideally should be corrected instantaneously, so as to provide a linear distribution throughout the test without sharp fluctuations.

Servo-valves allow flow control based on the continual output of the servo-loop controller. This way of working allows the control of both the direction and quantity of the flow and, finally, the load exerted on the specimen, based on its stiffness.
To control the snap-back softening instability along with the high sensitivity of the feedback loop, the system stiffness of the testing machine inclusive of load frame, load cell, and support fixture shall by far exceed that of the specimen. It should therefore be greater than 200 kN/mm [2]. Due to the size of the round panel the distance between the columns of the frame is at least 900 mm. Moreover, the shape of the frame should allow easy and practical loading.

The machine, fully controlled by PC, should offer dedicated software capable of combining client, contractor, mix design, and field data with the test results. Reports are transferred to a computer running the database program and automatically imported into the database tables. The computer running the database program can be connected to a web server that has separate, secure folders for each client and contractor where the customer has immediate online access.

Modern systems assuring reliable results towards a consistent characterization of the structural behaviour and the ability to communicate with other computers and programs running on their corporate network, are making testing more efficient and reliable, increasing productivity and reducing costs.

Literature

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FURTHER INFORMATION

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