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Data Article

Experimental quantification of punching shear capacity for large-scale GFRP-reinforced flat slabs made of synthetic fiber-reinforced self-compacting concrete dataset

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ABSTRACT

This article provides experimental data on the punching shear behavior of synthetic fiber-reinforced slabs reinforced with glass fiber reinforced polymer (GFRP) bars and cast from self-consolidating concrete (SCC). The data was collected from tests performed on six full-scale specimens centrically loaded until failure as indicated by penetration of the column stub into the slab and achieving a sharp drop in the load carrying capacity. Three different reinforcement bar spacings were used to consider the effect of reinforcement ratio on punching shear resistance. Three of the specimens tested were reinforced by 1.25% of volume of synthetic fiber, and three were control specimens cast from regular SCC. Applied load, central deflections, and bar strain were monitored during the experiment and are provided in the supplementary data. Any future models for analyzing the punching shear behavior and capacity of flat slabs reinforced with GFRP rebars will find this data valuable for model validation, and for establishing suitable safety factors for design. Numerical studies on the simulation of fiber-reinforced concrete would also find value in this data to validate the numerical model and enable it to be used for further studies.

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Specifications Table

Subject	Civil and Structural Engineering
Specific subject area	Concrete structures, GFRP composites
Type of data	Table Chart
How data were acquired	The data presented in this paper was obtained from large-scale tests on GFRP-reinforced synthetic-fiber reinforced SCC slabs subject to monotonically increasing concentric loading. Load was applied using a hydraulic jack, central deflections were tracked using a linear transducer and strains were monitored via strain gauges glued on the GFRP bars.
Data format	Raw Analyzed Filtered
Parameters for data collection	Monotonically applied concentric loading increasing at a rate of 5 kN/min. The parameters tracked were central deflection, rebar strain, and applied load.
Description of data collection	Data was collected as sets of excel sheets saved from the instruments. The central deflection and central load were collected in a separate set of files from the strain gauge data. The data is now combined in one excel file containing load, deflection, and strain gauge readings data.
Data source location	Institution: The American University of Sharjah (AUS) City: Sharjah Country: UAE
Data accessibility	AlHamaydeh, Mohammad; Orabi, Mhd Anwar (2021), “Experimentally-Measured and Analytically Derived Data on Punching Shear of GFRP-Reinforced Flat Slabs made from SCC and SNFRC_Dataset”, Mendeley Data, V3, http://doi.org/10.17632/gh9zh5x54r.3 Direct URL to data: http://doi.org/10.17632/gh9zh5x54r.3
Related research article	AlHamaydeh, M.; Orabi, M.; "Punching Shear Behavior of Synthetic Fiber-Reinforced Self-Consolidating Concrete Flat Slabs with GFRP Bars," ASCE, Journal of Composites for Construction, 2021, http://doi.org/10.1061/(ASCE)CC.1943-5614.0001131.

Value of the Data

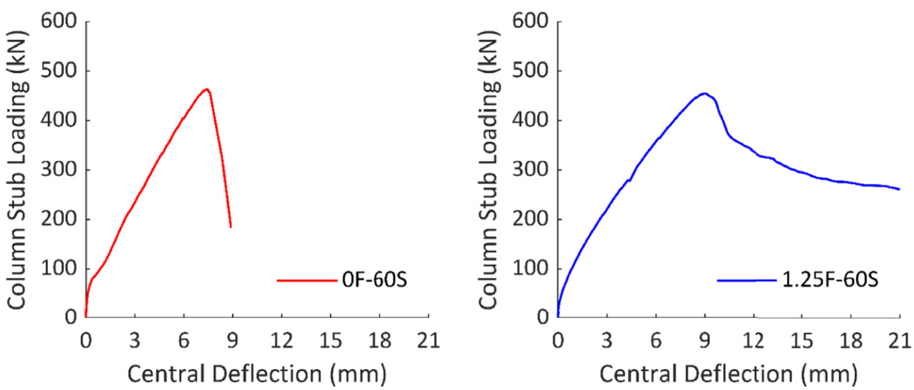
- The experimental data presented on behavior of GFRP-reinforced flat slabs made of synthetic fiber-reinforced concrete can be used in designing flat slab systems for punching shear in highly corrosive environments.
- Researchers conducting numerical, analytical, and experimental studies on the punching shear behavior of flat slabs or on the benefits of synthetic fiber in strengthening concrete structures will find this data particularly useful. Engineers and designers considering integration of corrosion-resistant slab-column connections into their structures would also recognize the value of this data for their projects.
- Researchers can use the force-deflection plots presented here to assess the accuracy and validity of their numerical and analytical models in predicting the pre- and post-cracking stiffness of slab-column connections.
- This data set comes from experiments performed on a type of slab-column connection that is composed of completely non-ferritic material and is thus highly corrosion resistant. This combination of material has not been tested before and provides a unique and valuable set of data for wide-use deployment purposes.

1. Data Description

Experimental data for the punching shear behavior of six large-scale specimens is presented in this data article, and is based on work reported in [1,2]. The specimens were labelled based on their rebar spacing and fiber content. Accordingly, specimen 0F-60 has 0% fiber content (no fiber), and its flexural reinforcement is spaced at 60 mm on center. Likewise, specimen 1.25F-110S has 1.25% fiber content and its reinforcement bars are spaced 110 mm apart. The details for each specimen are shown in the excel file 'SpecimenDetails.xlsx' under the sheet titled 'Properties', including the reinforcement ratio and average concrete cube strength. Properties of the reinforcement used are also included. In that file, calculated properties such as effective depth and critical perimeter are clearly identified from measured properties such as slab length and measured bar diameter. The experimental data for load-deflection behavior of each specimen is provided in the sheet 'LoadDeflection' in the supplementary excel file. This sheet also contains the data for the rotation of the slab calculated based on the assumption of rigid-segment rotation from d/2 away from the face of the column until the face of the support. This data is operated upon by the supplementary MATLAB file 'Plots.m' which is used to produce Fig. 1.

The first three specimens presented correspond to the specimens without fiber (0F) and the later three correspond to the specimens without fiber 1.25% fiber content (1.25F). Samples of the specimens punching shear behavior are presented in Fig. 1. The experimental capacities of all tested specimens including load at first crack, ultimate load, as well as toughness and maximum reinforcement toughness are summarized in 'Properties' from 'SpecimenDetails.xlsx'. The toughness of each specimen was calculated by taking the area under the load-deflection curve which is performed in both the excel and MATLAB supplementary files using the trapezoidal rule.

The final sheet 'BarStrain' of the supplementary excel contains the experimental data for the strain in the reinforcement bars based as recorded by the stain gauges glued on the two central bars in the slabs. Samples of both the higher strain values (strain 1) corresponding to the reinforcement on the outer layer of reinforcement and the lower strain values (strain 2) are plotted in Fig. 2.



(a) (b)

Fig. 1. Sample load-deflection behavior (a) 0F specimen; (b) 1.25F specimen.

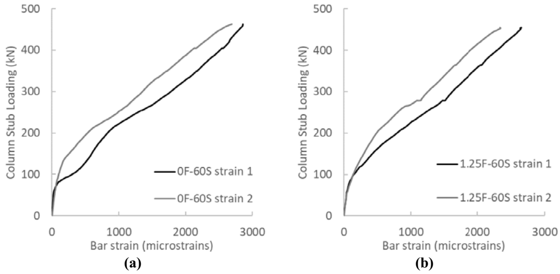


Fig. 2. Sample reinforcement strain profile (a) 0F specimen; (b) 1.25F specimen.

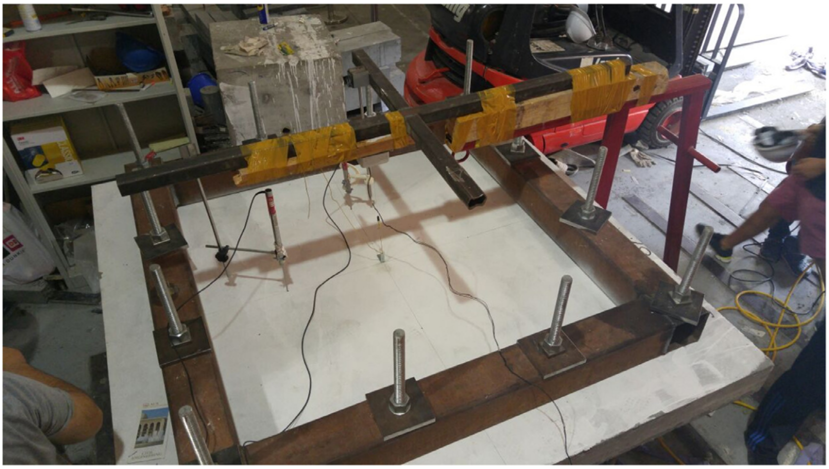


Fig. 3. Experimental setup and instrumentation.

2. Experimental Design, Materials and Methods

Six specimens with a footprint of 2 m × 2 m, a depth of 0.15 m, cast with a 0.25 m × 0.25 m square column stub also 0.15 m deep were built. The specimen dimensions correspond to realistic construction dimensions and are in line with other experimental research in the area such as [3,4]. The experimental scheme and instrumentation is shown in Fig. 3. The concrete mix used for the experimental program had a water-cement ratio of 0.5, and used a maximum aggregate size of 20 mm. The mix had a specified strength of 50 MPa but on the day of testing achieved a crushing capacity of 48 MPa. As the figure shows, a linear transducer recorded the central slab deflection, while LVDTs were used ensure symmetry conditions are maintained throughout the experiment. For more details, the reader is kindly referred to this related technical article [5]. Moreover, strain gauges were fixed to the middle of the central rebars in both directions. The first three specimens 0F-60S, 0F-80S, and 0F-110S were not reinforced with synthetic fiber, while the remaining three specimens all had a fiber content of 1.25% of their concrete volume. The first three were cast from the same concrete batch and therefore had the same mean concrete cube strength of 47.7 MPa with a standard deviation of 2.5 MPa. The second set of specimens had a mean cube strength of 49.8 MPa with a standard deviation of 1.7 MPa. Each set of specimens utilized three reinforcement ratios of 2.81%, 2.11%, and 1.53%, which correspond to a bar spacing of 60 mm, 80 mm, and 110 mm respectively all with 25 mm concrete cover. The high reinforcement ratios used ensure that punching shear dominates the behavior and that flexural failure would not take place. The column stub was reinforced with eight 16 mm diameter steel bars wrapped with 8 mm ties at 50 mm intervals. The column reinforcement corresponds to a reasonable reinforcement ratio of about 2.5% and was arranged to be similar to typical detailing in construction. The selection of steel reinforcement for the column stub instead of GFRP was made due to logistical constraints and is not expected to affect the behavior of an otherwise nonferritic connection. The flexural reinforcement sand coated GFRP bars used in the slab were No. 16 bars with a measured diameter of 15.34 mm and had an ultimate strength of 1043 MPa with a Modulus of elasticity equal to 50.6 GPa. The two central GFRP bars in each specimen were equipped with a strain gauge glued to their surface. The synthetic fibers used in the samples were inert macro polyolefin synthetic fibers with 0.5 mm diameter and length of 50 mm resulting in an aspect ratio of 100. The tensile strength of these fibers was high at 600 MPa, but the modulus of elasticity was quite low at only 11 GPa.

The tension side of the slab faced up, and thus the column stub protruded downwards. A rubber plate was placed on the bottom face of the column stub, and below it was a steel plate and a load cell. Below the load cell was a hydraulic jack used to apply concentric monotonic load to the slab. The slabs were supported on the top by a 1.65 m $\times$ 1.65 m square steel frame built up from 0.15 m $\times$ 0.15 m hollow square sections that were 25 mm thick. The steel frame supported by twelve 30 mm diameter steel anchor rods. The rods were fixed to the strong floor of the laboratory and passed through 50 mm diameter circular holes cast into the slab 250 mm away from its edge.

The line of a linear transducer was affixed to a steel angle glued to the center of the specimens and was used to track the central deflection. LVDTs were also used to track deflections at the halfway point between the center of the slab and the centerline of the supporting frame. During the experiment, the loading jack applied a monotonically increasing load at a rate of 5 kN/min. First occurrence of cracking was observed, and both its load and corresponding displacement were recorded. Punching shear was assumed to occur when a sharp drop in the load carrying capacity was observed along with penetration of the column stub into the specimen. The experimental capacities as well as their corresponding deflections are also available from the ‘Properties’ sheet in the excel file ‘SpecimenDetails.xlsx’.

Ethics Statement

This data article is in full compliance with the ethical requirements for publication in *Data in Brief.*

CRediT Author Statement

Mohammad AlHamaydeh: Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision, Project Administration; **Mhd Anwar Orabi:** Methodology, Investigation, Data Curation, Writing - original draft Preparation, Writing - review & editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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