Discussion: Torsional behaviour of prestressed concrete girder with precast box segments

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Contribution by J. R. Martí-Vargas

The discussed paper (Kim *et al.*, 2014) presents an experimental study of spliced precast prestressed concrete girders to evaluate torsional performance, based on the method of connecting segments. Three types of joints were examined in terms of the crack and failure pattern, maximum torque (T_u), torsional stiffness and torsional ductility. The authors should be complimented for providing this detailed paper that is of interest to the discussor, who would like to offer some comments for their consideration and response, mainly about details of the specimens and test results.

Each specimen was fabricated by splicing two segments through steel box tubes inserted into hollow sections to improve girder strength. Two of the five specimens were designed by using steel tubes that differed in size: a $200 \times 200 \times 6$ mm steel tube protruded from one concrete segment and a $186 \times 186 \times 6$ mm steel tube was embedded in the other concrete segment. The authors state that the protruding steel tube was inserted into the other steel tube. However, it seems that the protruding steel tube should be the smaller one rather than the bigger one, and that the hollow section of the corresponding concrete segment should be 186×186 mm instead of 200×200 mm, as shown in Figure 2 in the paper. Furthermore, the discussor believes that the difference in size results in a gap of 7 mm between the two steel tubes on all sides (if a perfectly centred insertion is assumed). This may result in a certain limitation in terms of the collaboration of the two steel tubes until a considerable twist angle is achieved. Perhaps this may explain the lowered torque upon crack occurrence in the two SGI specimens, and also the fact that there is no reason for a lower crack load (36 versus 43 kN) when a longer overlap length (600 versus 300 mm) is used.

The crack patterns are shown in Figure 4 in the paper. However, the discussor could not find the locations of the

overlap lengths in the SGI specimens and the length inserted into the SGC specimen. In order to offer a better understanding, can the authors provide additional details on these issues?

Ductility performance was evaluated through the ratio $\phi_{0.8\max}/\phi_{cr}$. The discussor is confused about the two definitions of $\phi_{0.8\max}$: the twist angle when the initial angle reached $0.8T_u$, and the twist angle when the initial angle of ϕ_{cr} reached T_u , and then the torque maintained at $0.8T_u$. Furthermore, in Figure 6, the torque–twist curves for specimens SGI and SGC differ from those for specimens MG and SGW: the former display a softening branch where point $0.8T_u$ is identifiable, whereas the latter depict a practically horizontal branch after T_u is reached. One main result is that the ductility of specimen SGW is about 40% higher than that of specimen MG. However, it seems that the $\phi_{0.8\max}$ values in Table 6 do not correspond to $0.8T_u$ for specimens MG and SGW. It is noteworthy that: the value 0.0449 rad/m for specimen MG is near the twist angle at T_u ; the value 0.0640 rad/m is not depicted in the SGW curve; and, according to the abstract, specimen SGW had around five

Figure 2. Torque versus angle of twist

times the twist angle compared with the other specimens, which seems an unsupported result. These points should be clarified.

Authors' reply

The authors appreciate Professor Martí-Vargas' interest in the paper and his discussion comments. The three issues he raises are discussed below.

(a) The inside dimension of the larger tube was 188 mm and the outside dimension of the smaller tube was 186 mm, leaving a nominal 1 mm gap all around. This produced a tight fit, and no 'take-up' was observed on initial application of the load. The post-peak softening response was likely affected by relative slip between the tube surfaces at the splice as the deformations increased.

(b) As requested, we have added the locations of the splice details to Figure 4 as shown here in Figure 1.

(c) To evaluate the ductility performance, a ductility index μ was calculated as the ratio $\phi_{0.8\max}/\phi_{cr}$, where ϕ_{cr} is the twist angle upon crack occurrence and $\phi_{0.8\max}$ is the twist angle occurring when the torque dropped to 80% of the maximum torque in the post-peak range. This definition was applied directly to the SGI and SGC specimens, which displayed significant post-peak softening immediately after reaching the maximum torque. However, for the MG and SGW specimens the test was terminated before the load dropped to 80% of the maximum torque. Therefore, in these cases, the angle of twist occurring at 90% of the maximum torque was used as a conservative value for ductility. In Figure 6, some of the data points

Figure 1. Crack pattern: (a) MG; (b) SGW; (c) SGI 300; (d) SGI 600; (e) SGC and splice locations

were obscured by the text boxes for MG and SGW. The figure is reproduced here as Figure 2 to display the obscured data points. Figure 2 clearly demonstrates the improved post-cracking performance of MG and SGW compared with the SGI and SGC specimens.

REFERENCE

Kim MS, Scanlon A, Kang J and Lee YH (2014) Torsional behaviour of prestressed concrete girder with precast box segments. *Magazine of Concrete Research* **66(11)**: 576–584.