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Beam Test for Evaluating Applicabillity of High - Strength Reinforcement in Structure of Nuclear Facility

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1. Introduction

The structure of a nuclear facility is easy to be non-economic due to its large amount of rebar and it can also have a poor quality of concrete due to material segregation. Therefore it is necessary to reduce the amount and the density of rebar and this requires the development of the structural design using high-strength rebar. The high-strength rebar which has high yield strength can reduce the amount of rebar in concrete and widen its spacing so that it has better workability and higher economic benefits for the structure. However, the maximum yield strength of rebar is limited to 420MPa in the design criteria for structure of nuclear facility in Korea and USA. Korea Hydro & Nuclear Power is progressing research to revise the limitation in the yield strength of rebar, which is suggested in the criteria of KEPIC and ACI, in order to apply 550 MPa high-strength rebar for the construction of a nuclear facility. This study is to review the applicability of high strength rebar in structure of a nuclear facility through a model beam test.

2. Test methods and plan

2.1 Test plan
Six reinforced concrete beams, each having differences in rebar spacing and yield strength, are prepared to evaluate the usability and behavior of the beams with high-strength shear reinforcement based on ACI349-06(KEPIC-SNC) applied for the structure of a nuclear facility. The yield strengths of shear rebar are three types which are 334, 480 and 667 MPa. Numbers 2,3 and 4 models have a higher strength of shear reinforcement and the same spacing between bars. Numbers 5 and 6 have wider spacing of 120 mm and 160mm according to yield strengths of the shear reinforcement and this leads to a similar amount of shear reinforcement as the other models with normal strength shear reinforcement. The concrete strength is fixed to 42Mpa as applied to the structure of a nuclear facility.

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Beam	f'_c	Longitudinal tensile bars		Shear steel bars			b	h
	(MPa)	ρ_l (%)	f_{lt} (MPa)	s (mm)	ρ_v (%)	f_{vt} (MPa)	(mm)	(mm)
B42-1	42.1	5.6	648	-	-	-	350	480
B42-2	42.1	5.6	648	100	0.724	334	350	480
B42-3	42.1	5.6	648	100	0.724	480	350	480
B42-4	42.1	5.6	648	100	0.724	667	350	480
B42-5	42.1	5.6	648	120	0.603	480	350	480
B42-6	42.1	5.6	648	160	0.453	667	350	480

Table 1

2.2 Test methods
The cross-section of the model beam is 350mm(W) x 480mm(D). The detail of the beam is shown in Figure 1. The ratio of flexural tensile reinforcement in the model beam is higher than that in other parts of structure. This is so each model will have shear failure before flexural tensile failure in order to figure out exactly how much the high-strength shear reinforcement contributes to reducing shear. Except for no.1 without stirrup, the others used are hook type closed stirrup and complied with the minimum and maximum ratio and spacing of rebar as specified in ACI349-06. This study is to check if shear strength and rebar yield before the concrete.

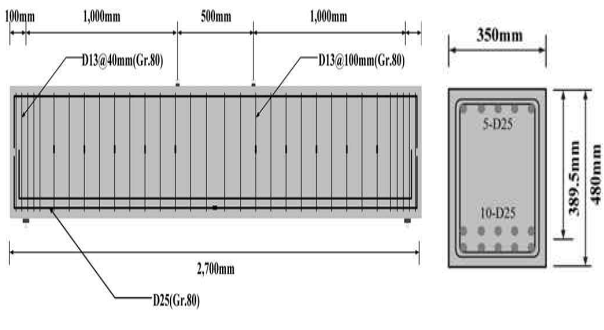


Figure 1

3. Test results

3.1 Shear strength

Numbers 2,3 and 4 models and numbers 2,4 and 6 are compared to show how different shear capacities varied according to yield strength. Figure 2 shows the shear capacity of the beam with stirrups having a different tensile strength and Figure 3 shows the shear capacity of the beam featuring the higher strength of stirrups and wider spacing of them, in other words, with almost the same amount of shear reinforcement. When the spacing of the stirrups are the same that is when the amount of shear reinforcement increases, the shear capacity shows a nearly linear increase. When the amounts of shear reinforcement are the same between them, the model beam with a wider spacing of high strength shear rebar and the model beam narrower spacing of normal rebar are the same in maximum loads of the model.

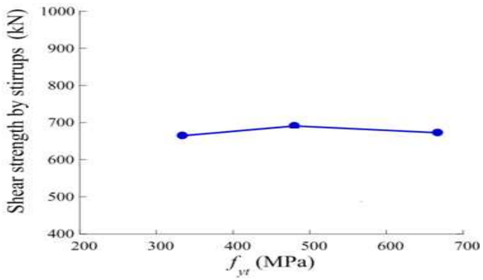


Figure 2

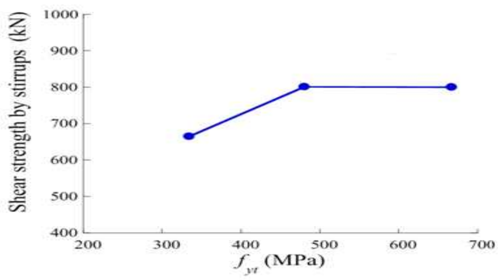
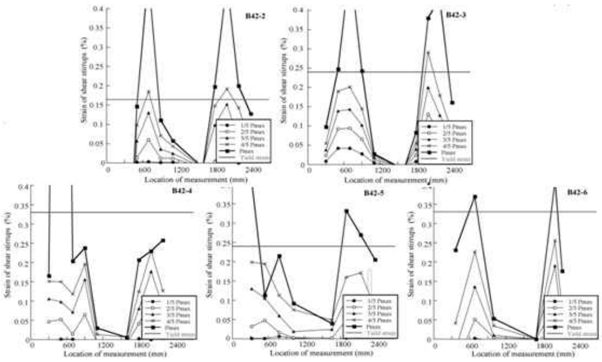


Figure 3

3.2 Yield of rebar

One of the reasons for limiting maximum yield strength is to prevent concrete from fracturing by compaction before shear reinforcement yields. There is a high possibility that concrete is fractured by compaction before shear reinforcement yields as high-strength shear reinforcement has big yield strain ratio.

This study evaluates shear failure modes in the beams using high-strength shear reinforcement which has higher strength than 420MPa which is a maximum value limited in ACI349-06. The shear reinforcement yield is observed using the strain ratio gauge attached to each shear reinforcements. Figure 4 shows the change of strain ratios of the shear reinforcement according to five levels of load. On the figure, X-axis represents the location of the gauge attached to each spot and Y-axis represents the strain ratio of shear reinforcement measured by different levels of load. On the levels of load, P_{max} shows the distribution of the strain ratio reached maximum load, 3/5 P_{max} represents the distribution of the strain ratio reaching 3/5 of the maximum load. When looking at figure 4, it shows that the high-strength reinforcement yields before maximum load is applied in all models including no. 4 and 6 using 667Mpa of high-strength reinforcement.



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4. Conclusion.

After reviewing the shear capacity and reinforcement yield to assess the applicability of high-strength reinforcement in the structure of a nuclear facility, we make the following conclusions.

When using high shear reinforcement with wider spacing, it has a similar shear capacity to normal reinforcement with narrower spacing. This means better workability and economic benefits can be achieved by widening the rebar spacing without brittle fracture in the elements. For future plans, the results of this test and supplementary test will be submitted to ACI349 committee as backup data to revise the standard for yield strength of high-strength rebar.

ACKNOWLEDGMENTS

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