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Transfer length in pretensioned prestressed concrete beam using high strength PS Strand

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ABSTRACT

Prestressing steel strand is used for the pre-compression of concrete so that the concrete structures can be larger and longer such as bridges and storage tanks. Higher strength is required than any other structural steel to design more efficient and effective structures. Recently, newly developed 2,400 MPa PS strand is increasing its application by substituting for 1,860 MPa grade in the post-tensioned structures. However, there has not been regulation nor research on the use of 2,400 MPa strand in pretensioned prestressed concrete structures. In this study, transfer length tests were conducted for 1,860MPa and 2,400MPa strands and the influence of compressive strength of concrete, steel fiber volume ratio, reinforcement of stirrup, and pretension loading type was analyzed. It was found that the transfer lengths of 2,400MPa strand were increased 7~11% at cut end and 3~11% at dead end compared with 1,860MPa strand even though the strength of the strand increased 29%.

1. INTRODUCTION

Pretensioned prestressed concrete members have been widely used in the construction industry because high-quality fabrication is possible and it can be easily and fast assembled in the construction fields. The transfer of prestress force and the transfer length are of great concern because it directly affects the distribution of prestress in the pretensioned members (Oh et al., 2014).

Recently, newly developed 2,400 MPa PS strand is increasing its application by substituting for 1,860 MPa grade in the post-tensioned structures. However, there has not been regulation nor research on the use of 2,400 MPa strand in pretensioned prestressed concrete structures. In this study, transfer length tests were conducted for 1,860MPa and 2,400MPa strands and the influence of compressive strength of concrete, steel fiber volume ratio, reinforcement of stirrup, and pretension loading type was analyzed.

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2. Test Specimens

Table 1 Test specimens

No.	Design strength of concrete (MPa)	Compressive strength of concrete (MPa)	Tensile strength of PS strand (MPa)	Fiber (%)	Stirrup (mm)
#1	50	49	1860	0	0
#2	50	49	1860	0	0
#3	80	64	1860	0	0
#4	80	64	1860	0	0
#5	50	49	2400	0	0
#6	50	49	2400	0	0
#7	80	64	2400	0	0
#8	80	64	2400	0	0
#9	50	49	2400	0.38	0
#10	50	49	2400	0.76	0
#11	80	64	2400	0.38	0
#12	80	64	2400	0.76	0
#13	50	49	2400	0	8@50=400
#14	50	49	2400	0	8*@50=400
#15	50	49	2400	0	16*@50=800
#16	50	49	2400	0	16*@50=800
#17	50	49	2400	0	24*@50=1200
#18	50	49	2400	0	24*@50=1200
#19	80	64	2400	0	8*@50=400
#20	80	64	2400	0	8*@50=400
#21	80	64	2400	0	16*@50=800
#22	80	64	2400	0	16*@50=800
#23	80	64	2400	0	24*@50=1200
#24	80	64	2400	0	24*@50=1200
#25	50	49	2400	0	12*@100=1200
#26	50	49	2400	0	12*@100=1200
#27	80	64	2400	0	12*@100=1200
#28	80	64	2400	0	12*@100=1200

Design variables of 28 specimens can be found in Table 1. In order to obtain reliable results, two specimens were fabricated with same design variables except for specimens with steel fibers in them. Specimens with same concrete strength were fabricated using same concrete batch. Every two specimens were prestressed with one PS strand and the two have same design variables (Fig. 1). Prestressing force was transferred to concrete by sudden release between two specimens on a strand.

Therefore, every specimen has one cut end on the strand cutting side and one dead end on the opposite side. Mechanical properties of 2,400MPa are same as 1,860MPa except for yield and tensile strengths. Geometry of specimens can be seen in Fig. 2. Strains on the surface of concrete were measured using mechanical strain gages along with electrical strain gages. The mechanical and electrical strain gages were installed up to 1,350mm from the end face of concrete on every 50mm and 100mm, respectively.

Table 2 Mechanical properties of PS strands

Tensile strength (MPa)	Diameter (mm)	Yield load (kN)	Tensile load (kN)	Relaxation (%)
1,860	15.2	222	261	2.5%
2,400	15.2	283	333	2.5%

Fig. 1 Fabrication of pretensioned prestressed concrete beams

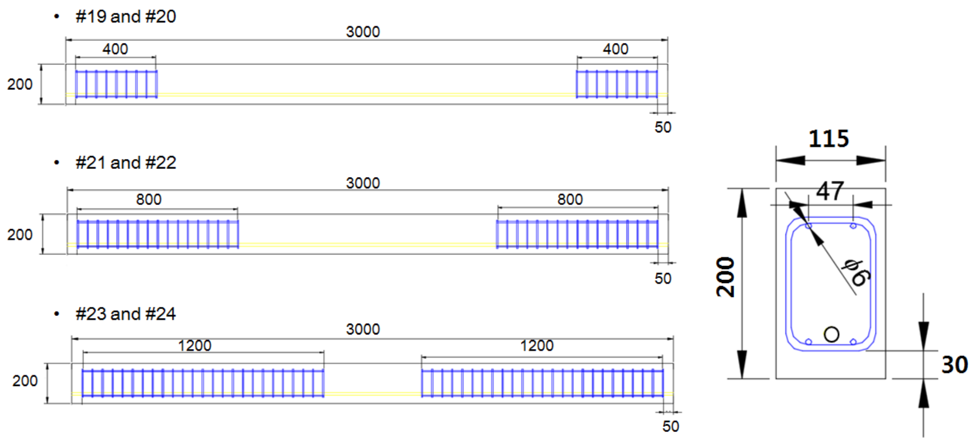

Fig. 2 Schematic diagram of stirrup installed test specimens

3. Test Results

The results (Fig. 3) show that transfer length at cut end is mostly larger than the result at dead end. Especially, as can be seen in compared transfer length from #1 to #8, prepared members with 1,860 MPa PS strand have about 15 % larger transfer length at cut end, and the result with 2,400 MPa PS strand shows about 22 % larger than the result of transfer length at dead end. The transfer lengths of 2,400MPa strand were increased 7~11% at cut end and 3~11% at dead end even though the strength of the strand increased 29%.

The compared results of members from #1 to #8 show that transfer length using 1,860 MPa PS strand is decreased about 9 % at cut end as increase of compressive strength of used concrete but dead end has similar transfer length with different compressive strength of concrete, but the transfer length using 2,400 MPa PS strand is decreased as increase of compressive strength at both ends. The decreased ratio is about 5% and 7% at cut end and dead end, respectively.

The transfer length in 49 MPa compressive strength of concrete is increased about 6 % and 11 % at cut end and dead end, respectively. However, the transfer length in 64 MPa compressive strength of concrete shows that the transfer length at cut end is increased about 11 % as high tension strength of PS strand is used, but the transfer length at dead end is increased 3 %.

The decrease of transfer length is occurred at cut end as increase of added steel fiber, its decreased trend is remarkable when high-strength concrete is used. The transfer length is decreased at cut end than dead end as increase of installation length, and its trend is noticeable when high-strength concrete is used.

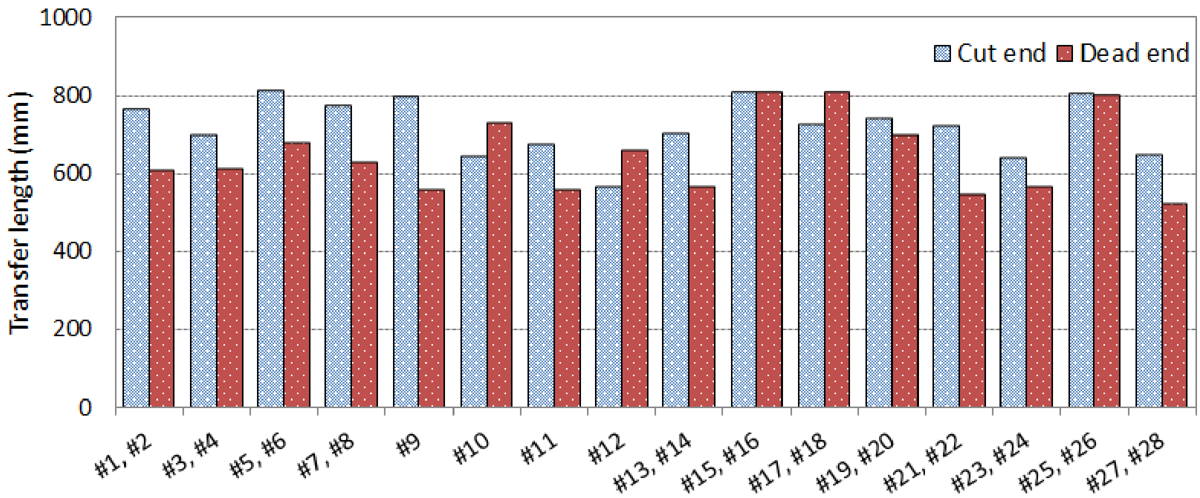

Fig. 3 Comparison of evaluated transfer length at cut end and dead end

3. CONCLUSIONS

In this study, transfer length tests were conducted for 1,860MPa and 2,400MPa strands and the influence of compressive strength of concrete, steel fiber volume ratio, reinforcement of stirrup, and pretension loading type was analyzed. It was found that the transfer length of 2,400MPa strand was increased 3~11% compared with 1,860MPa strand even though the strength of the strand increased 29%. The effect of higher strength in strand decreases as the concrete strength increases. The fiber and rebar was effective in reducing transfer length at cut end rather than dead end.

REFERENCES

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