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Dynamic response of a seven-wire strand during two different detensioning procedures

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ABSTRACT: Reported is a set of the dynamic strain changes of a seven-wire strand imbedded in a pretensioned concrete bar during flame-cutting and hydraulic-jacking procedures. To measure the dynamic response of the wires properly, the data was read 10,000 times per a second. In the case of the flame-cutting procedure, all the wires did not experience the same strain change during the procedure. The detensioning was completed with multiple sharp drops of the strain for few seconds. In the case of the hydraulic-jacking procedure, all the wires experienced almost the same smooth strain changes, although the detensioning was completed even faster than the flame-cutting procedure.

1 INTRODUCTION

Prestressing force is given by detensioning strands in a pretensioned structure. There are two different types of detensioning procedures depending on release methods, namely flame-cutting or hydraulic-jacking. It is known that pretensioned structures are affected by the detensioning procedures.

The flame-cutting procedure is applied to release a single-strand of a seven-wire strand. On the other hand, the hydraulic-jacking procedure is applied to release all seven-wires of the strand at the same time. These two types of procedure is completed within a few second and rapidly influences strain changes in the strand and concrete.

It is well known that bursting and spalling stress could make cracks in pretensioned structures during detensioning procedures. These cracks can be developed during detensioning procedures. Nanni et al. found cracks caused by the strain wedge effect during hydraulic-jacking detensioning (Nanni et al. 1992). Russell and Burns developed that dynamic shock effect could create crack in concrete by detensioning procedures (Russell & Burns 1997).

Oh & Kim showed that the detensioning procedure influences transfer length (Oh & Kim 2000). The transfer length of the pretensioned structure by flame-cutting procedure is larger than that by hydraulic-jacking procedure. In this paper, we compared strain change of strands and those of prestressing force in pretensioned structures by means of detensioning procedures to check the influence of detensioning procedures.

2 EXPERIMENT

2.1 *Test specimens*

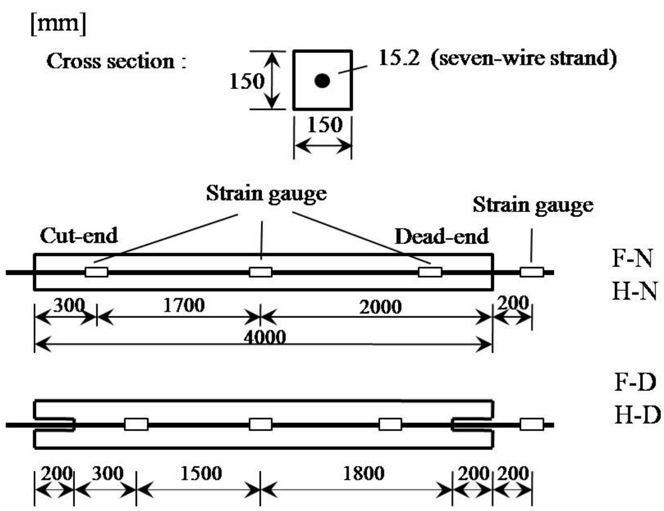

Figure 1. Test specimen.

To check the influence of detensioning procedures, we made four pretensioned specimens with seven-wire strands. The 4,000 mm length, 15.2 mm diameter strand was embedded in the 150 mm ×150 mm concrete bar like in Figure 1. Dimensions of all specimens are similar.

Table 1 presents classification of specimens. Each specimen is given by an ID that represents the detensioning procedure and debonded length. F and H are for the flame-cutting and hydraulic-jacking, D is for bonding region at the end of the specimen, repectively. N represents no debonding region.

Table 1. Outline of the test specimen.

specimen ID	Detensioning procedure	Debonded length [mm]
F-N	Flame-cutting	0
H-N	Hydraulic-jacking	0
H-D	Hydraulic-jacking	200
F-D	Flame-cutting	200

2.2 *Procedure of experiment*

Strands were placed in all specimens. PVC pipes were installed in specimen H-D and F-D for debonded region.

Strain gauges were attached on each seven-wire strand as in Figure 2 at four different regions: the cut-end, the center, the dead-end and the outer one. We got two different kinds of strain change data.

The cut-end, the center, the dead-end was installed in the specimens. To properly measure the dynamic response of the wires, the data was read 10,000 times per a second.

The outer one was exposed to the air for measuring prestressing force by static response. The data was read 2 times per a second. Prestressing force was calculated by elastic restoration from the difference between before and after detensioning.

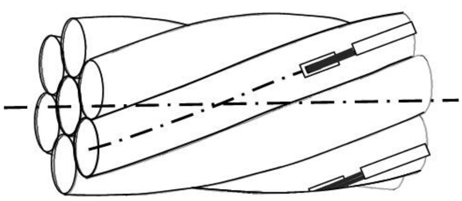

Figure 2. Strain gauge attachment.

3 EXPERIMENTAL RESULTS

3.1 *Strain changes*

Figure 3 indicates the strain changes at cut-end and the center in F-N specimens.

It took about 5 seconds to complete detensioning after flame-cutting was started. The tendency of strain change of gauge 1 is different from that of

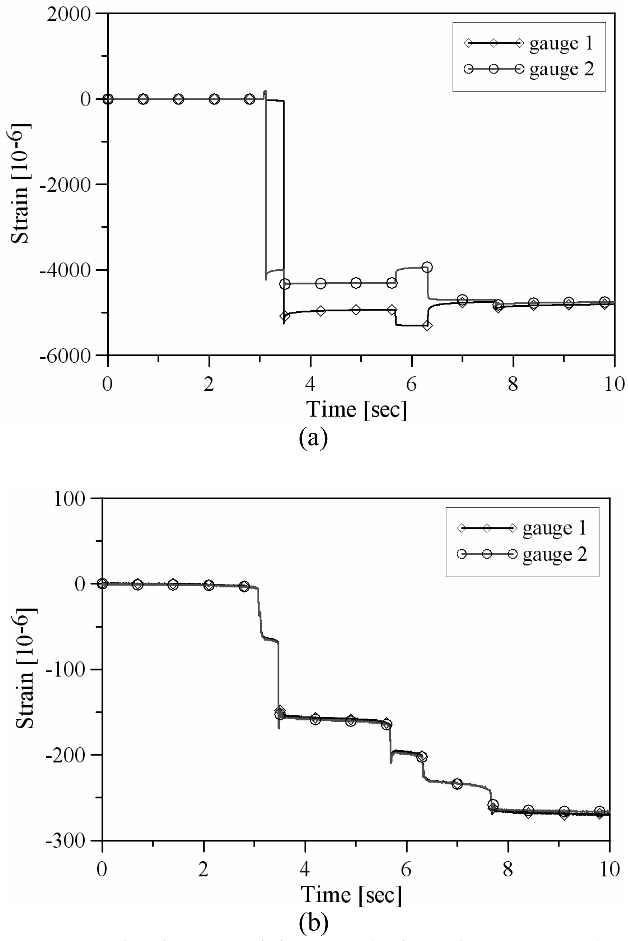

Figure 3. Strain changes of the strand of specimen F-N; (a) cut-end, (b) center.

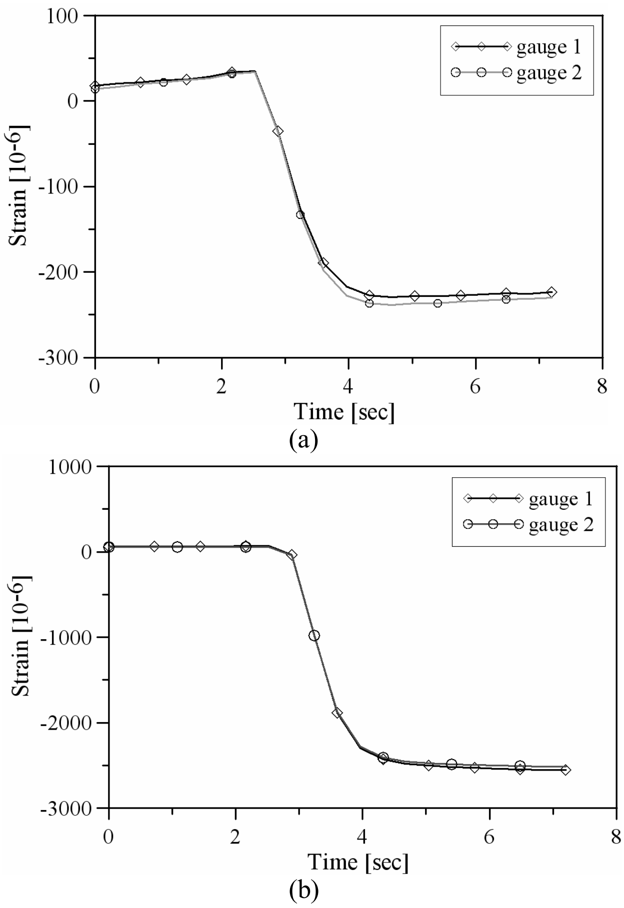

Figure 4. Strain changes of the strand of specimen H-N; (a) cut-end, (b) center.

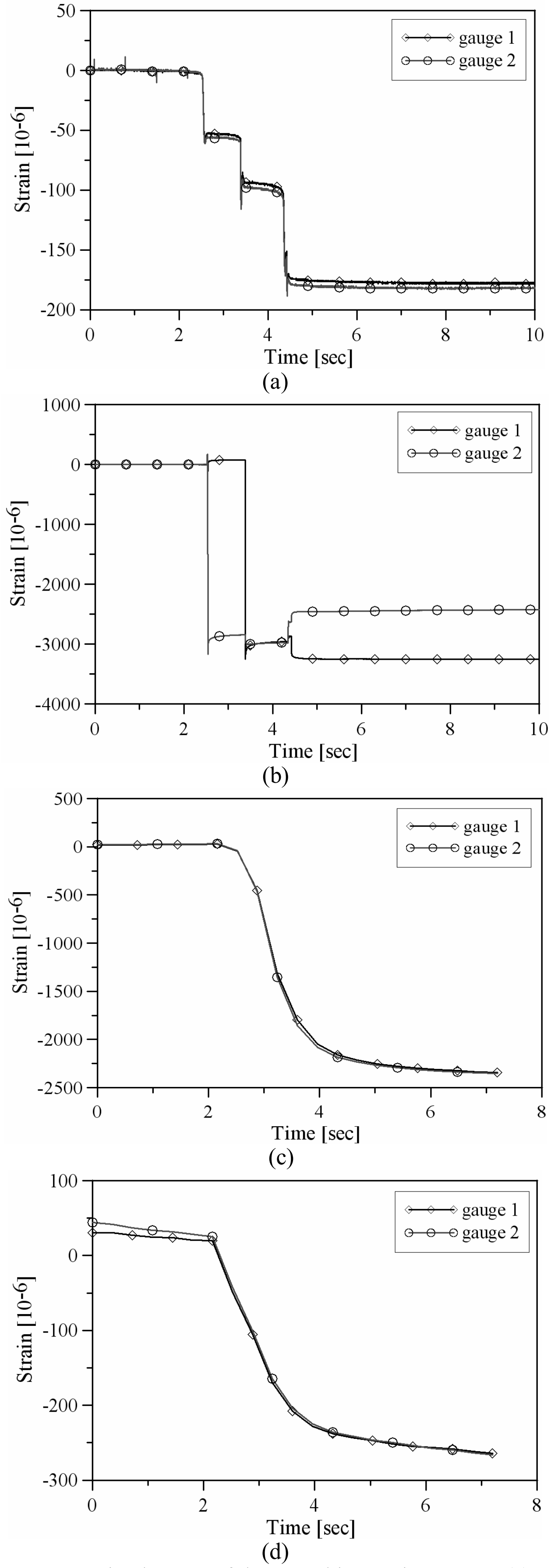

Figure 5. Strain changes of the strand in specimen F-D; (a) cut-end, (b) center, H-D; (c) cut-end, (d) center.

gauge 2 shown in Figure 3 (a). The strain of each wire at the cut-end differently underwent sharp drops as shown in Figure 3 (a). When we detensioned strands by flame-cutting, all the wires did not experience the same strain change so that each gauge showed several steps of strain changes due to individual cut of different wires. Dynamic shock by individual cut of different wires affected sudden strain change. For example, gauge 1 strain has a sudden change by a dynamic shock response at sixth seconds as in Figure 3 (a).

At the center of specimens, the tendency of strain change is nearly same at all the wire as shown in Figure 3 (b). The strain of each wire at the center jumped down almost same following the sequence of cutting wire. Unlike the result in Figure 3 (a), there were little sudden strain change between the wire by a dynamic shock response in Figure 3 (b).

Figure 4 shows the strain changes at the cut-end and the center in H-N specimens.

It takes about 1-2 seconds to complete detensioning after detensioning procedure was started using hydraulic-jacking. It was shorter than using flame-cutting. All strain histories are very similar behaviors in spite of different location of strain gauge as shown in Figure 4. Unlike what is shown in Figure 3, there is no sudden strain change by a dynamic shock response. All the wires experienced almost same smooth strain changes, although the detensioning was completed even faster than the flame-cutting procedures. The strain change of center is about 10% of that of the cut-end as shown in Figure 4 and nearly same strain histories.

Figure 5 shows that strain changes of the strand of specimen F-D and H-D. The tendency of strain changes is similar to Figure 3 & 4. On the other hand, the value of strain change is smaller than in Figure 3 & 4. The debonded region relieved the effect of dynamic shock by detensioning procedures. In the case of flame-cutting, Figure 3 & Figure 5 (a), (b), when debonded region was installed, strain change decreases about 20-30%. In the case of hydraulic-jacking, the effect of debonded region was relatively small, see Figure 5 (c), (d) and Figure 4.

3.2 *Prestressing force*

The prestressing force is transferred to concrete by detensioning strands. The difference between initial prestressing forces and residual forces of the strands could be thought to be loss of forces.

The initial prestressing forces were obtained using elastic restoration from the difference between before and after detensioning at the external strain gauge.

Figure 6 shows the difference between specimen F-N and H-N. Rate of y-axis means the ratio of residual prestressing force to initial prestressing force. Since the cut-end is in the transfer length, loss of prestressing force is larger than those of the center. On the other hand, there is little loss of prestressing force at the center. The ratio of residual prestressing force of flame-cutting specimen at the cut-end was greater than that of hydraulic-jacking specimen. It seems that detensioning using hydraulic-jacking is more useful than using flame-cutting.

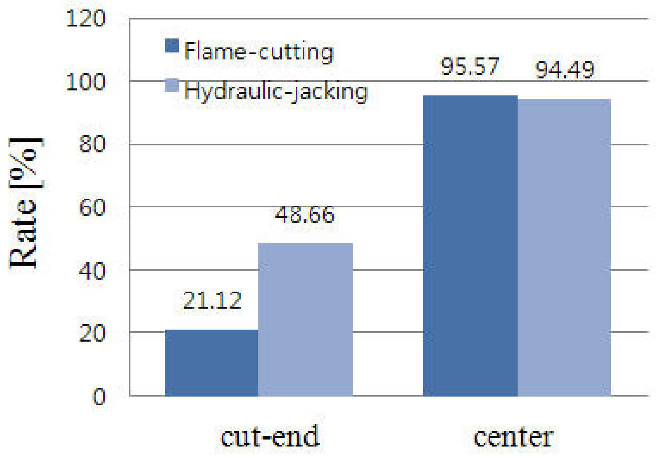

Figure 6. Comparison to prestressing force between F-N and H-N.

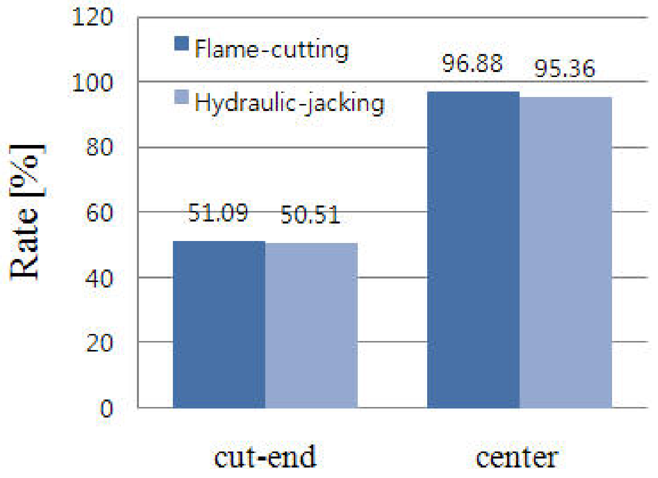

Figure 7. Comparison to prestressing force between F-D and H-D.

From Figure 7, the debonded region relieved the effect of dynamic shock by detensioning procedures like in section 3.1. It was almost same residual prestressing forces that using hydraulic-jacking and flame-cutting.

4 CONCLUSIONS

The dynamic response of wires is obtained from the strain gauges attached to the strands embedded in concrete bars. The results of this study can be summarised as follows:

(1) All the wires did not experience the same strain change during flame-cutting procedure. Dynamic shock by individual cut of different wires affected multiple sharp drops of the strain.
(2) All the wires were detensioned at the same time by hydraulic-jacking procedure. There were no sharp drops of the strain. The strain smoothly decreased.
(3) It took about 1-2 seconds to complete detensioning after detensioning procedure was started using hydraulic-jacking. Loss of prestressing forces of the strands using hydraulic-jacking were smaller than using flame-cutting.

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