# Use of Grade 80 Reinforcement in Oregon

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Chehalem Creek Bridge used for comparison of Grade 60 and Grade 80 reinforcement for 8-ft-diameter drilled shafts. All Photos and Tables: Oregon Department of Transportation.

In 2012, two local agency projects in Oregon used ASTM A706, Grade 80 steel reinforcement in large diameter drilled shafts for crossings of the Willamette River in Portland. One is the Tilikum Crossing, a cable-stayed bridge carrying a transit line and pedestrians, which is owned by the city of Portland. The other is the Sellwood Bridge, a steel deck arch, which is owned by Multnomah County.

In August of 2012, the Oregon Department of Transportation (ODOT) added guidelines for use of ASTM A706 Grade 80 steel reinforcement to their *Bridge Design and Drafting Manual* (BDDM). These guidelines were developed from discussions with an Oregon reinforcing bar manufacturer who confirmed both availability and the approximate cost premium for Grade 80 reinforcement.

**ODOT is ready to move forward with expanded use of Grade 80 reinforcement.**

Since those initial projects, only one additional project has used Grade 80 reinforcement. This lack of progress is primarily due to an Oregon shift in priority towards bridge repairs instead of replacements. This shift is a result of limited availability of bridge funding. However, ODOT is hopeful funding will improve in the near future. When that happens, ODOT is ready to move forward with expanded use of Grade 80 reinforcement.

Oregon anticipates increased use of ASTM A706 Grade 80 for the following reasons:

- The stress/strain curve for Grade 80 has a similar shape compared to Grade 60. This is not the case for reinforcement grades higher than 80 ksi.
- Grade 80 has an additional 33% yield strength compared to Grade 60, with only 10 to 12% additional material and fabrication cost.
- Good ductility. No. 3 thru No. 11 bars have a minimum elongation of 12%.
- Weldability.
- Reduced congestion.
- Availability.

Design with Grade 80 reinforcement uses the same processes and equations used for Grade 60 reinforcement. The American Association of State Highway and Transportation Officials (AASHTO) has confirmed this and raised the permitted yield strength from 75 to 100 ksi in the *2013 Interim Revisions of the AASHTO LRFD Bridge Design Specifications*.

Availability of Grade 80 reinforcement is improving due to increased use of Grade 80 reinforcement in the building industry. At this time, a minimum order of 50 tons for each size and cut length is recommended by rolling mills in the Oregon market. This minimum order size is mentioned several times in the following discussion, but will likely differ for each rolling mill and local market.

The following applications are good opportunities to use Grade 80 reinforcement:

- Drilled shafts: both longitudinal and lateral reinforcement
- Bridge decks: especially if design can be limited to a single bar size

- Crossbeams: for main flexural steel, use same bar size top and bottom

Oregon does not recommend using Grade 80 reinforcement in columns or other members that require the ability to form a plastic hinge under seismic loading. Research is ongoing to support use of Grade 80 reinforcement in these applications, but is not complete at this time. Early research results are promising.

## Design Examples

Use of Grade 80 reinforcement will reduce steel quantity and cost. Three examples are presented to illustrate the potential cost savings:

- Drilled shaft: 8-ft-diameter by 100-ft-long drilled shaft with Grade 80 reinforcement for both longitudinal bars and lateral spiral bars
- Bridge deck: 82 ft by 277 ft bridge deck (22,800 $ft^2$)
- Concrete crossbeam: Two concrete crossbeams, 6 ft wide by 10 ft deep by 68 ft long

All three examples accounted for the increased splice lengths associated with Grade 80 reinforcement. All examples used $0.90 per pound for Grade 60 reinforcement and $0.95 per pound for Grade 80 reinforcement. Note that the 10% to 12% cost premium for Grade 80 reinforcement need only be applied to rolling cost, not the fabrication and installation cost. In many cases the fabrication and installation costs are also reduced because there are fewer bars to place and tie.

The Indian Creek Bridge used for comparison of Grade 60 and Grade 80 reinforcement for the reinforced concrete crossbeams.

Jackson School Road over Highway 47 Bridge used for comparison of Grade 60 and Grade 80 reinforcement for the reinforced concrete deck.

**Table 1. Comparison of the designs of 8-ft-diameter drilled shafts for the Chehalem Creek Bridge with Grade 60 reinforcement and Grade 80 reinforcement.**

| Reinforcement Grade | Grade 80 | Grade 60 |
|---|---|---|
| Longitudinal bars | Twenty-eight, No. 11, three-bar bundles (53,800 lb) | Thirty-six, No. 11, three-bar bundles (66,200 lb) |
| Transverse bars | No. 6 spiral at 4 to 8 in. spacing (8100 lb) | No. 6 spiral at 3 to 6 in. spacing (10,600 lb) |
| Total bar weight | 61,900 lb (19% less) | 76,800 lb |
| Cost | $58,800 (15% reduction) | $69,100 |

### Drilled Shafts

Drilled shafts are desirable candidates for Grade 80 reinforcement because they are known for having congested reinforcement and requiring only two bar sizes. Grade 80 bars can help alleviate congestion. Since drilled shafts are designed elastically in Oregon, seismic concerns do not prohibit use of Grade 80 reinforcement for this application.

As part of the Newberg-Dundee Bypass project in Oregon, 8-ft-diameter drilled shafts were constructed for the Chehalem Creek Bridge. These shafts averaged around 100 ft in length. Table 1 compares the design with Grade 60 reinforcement and Grade 80 reinforcement. In this comparison, the Grade 80 reinforcement option reduced the total steel weight by 19% and the steel cost by 15%. For the Chehalem Creek Bridge, the actual 2014 bid price was $0.77 per pound for Grade 80 reinforcement in the drilled shafts and $0.80 per pound for Grade 60 reinforcement used in other parts of the bridge.

For these drilled shafts, the longitudinal steel including splice lengths is around 85% of the total weight of reinforcement. Therefore, it would take two shafts of this size and length to reach the local minimum order quantity for longitudinal bars.

### Bridge Deck

Deck reinforcement is another logical location to consider using Grade 80 reinforcement. When Grade 80 reinforcement is used in a deck, it is usually possible to limit the bar size to a No. 4 bar. If so, longitudinal and transverse bars can both use the No. 4 size. When No. 4 bars are used in both directions, it is easier to meet the minimum order quantity.

Table 2 compares Grade 60 reinforcement with Grade 80 reinforcement for an overcrossing structure with a width of 82 ft and a length of 277 ft (22,800 $ft^2$). The design with Grade 80 reinforcement reduced the steel weight by 16% and the cost of the deck steel by 11% (around $13,000). With the smaller bar size, the Grade-80 reinforcement design had tighter spacing of the main flexural bars, which improves the performance against crack control. Note that this deck was large enough to reach the 50-ton minimum quantity.

**Table 2. Comparison of the designs of the reinforced concrete deck for the Jackson School Road over Highway 47 Bridge with Grade 60 reinforcement and Grade 80 reinforcement.**

| Reinforcement Grade | Grade 80 | Grade 60 |
|---|---|---|
| Transverse bars | No. 4 at 6.5 in. spacing in prestressed concrete girders<br>No. 4 at 6 in. spacing in cast-in-place concrete box girders | No. 5 at 7.5 in. spacing in prestressed concrete girders<br>No. 5 at 7.5 in. spacing in cast-in-place concrete box girders |
| Total bar weight | 110,800 lb (16% less) | 131,300 lb |
| Cost | $105,300 (11% reduction) | $118,200 |

**Table 3. Comparison of the designs of the reinforced concrete crossbeams for the Indian Creek Bridge with Grade 60 reinforcement and Grade 80 reinforcement.**

| Reinforcement Grade | Grade 80 | Grade 60 |
|---|---|---|
| Longitudinal bars | Nine, No. 11 bars top row<br>Twelve, No. 11 bars bottom row 2<br>Eighteen, No. 11 bars bottom row 1<br>(31,350 lb) | Twelve, No. 11 bars top row<br>Twenty, No. 11 bars bottom row 2<br>Twenty, No. 11 bars bottom row 1<br>(38,950 lb) |
| Transverse bars including temperature reinforcement | No. 6 stirrups at 8 in. (19,800 lb) | No. 6 stirrups at 6 in. (22,300 lb) |
| Total bar weight | 51,150 lb (16% less) | 61,250 lb |
| Cost | $48,600 (12% reduction) | $55,100 |

### Concrete Crossbeam

Concrete crossbeams often have high levels of reinforcement congestion. Use of Grade 80 reinforcement will certainly reduce congestion. Meeting crack control requirements may reduce some of the effectiveness of Grade 80 reinforcement. The example shown in Table 3 is for two 6-ft-wide by 10-ft-deep by 68-ft-long crossbeams for Indian Creek Bridge in Eastern Oregon. For this example, both flexural bars and stirrups were assumed to use Grade 80 reinforcement. Since the flexural bars for crossbeams were significantly larger than the skin (temperature) reinforcement, it would be reasonable to consider using Grade 80 reinforcement only for the flexural bars and keep the stirrups and skin reinforcement as Grade 60.

## Conclusion

Three applications of Grade 80 reinforcement have been considered. The savings in weight from using Grade 80 instead of Grade 60 reinforcement ranged from 16 to 18% with the expected cost reduction between 11 and 15%. Some designers may be reluctant to mix Grade 60 and Grade 80 reinforcement on the same project. If this is a concern, cost savings can still be expected if Grade 80 were used for everything. If so, reduced reinforcement congestion will be an additional benefit. Members which can potentially undergo plastic hinging in a seismic event should not use Grade 80 reinforcement until research that is currently in progress can confirm whether this restriction is necessary.

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