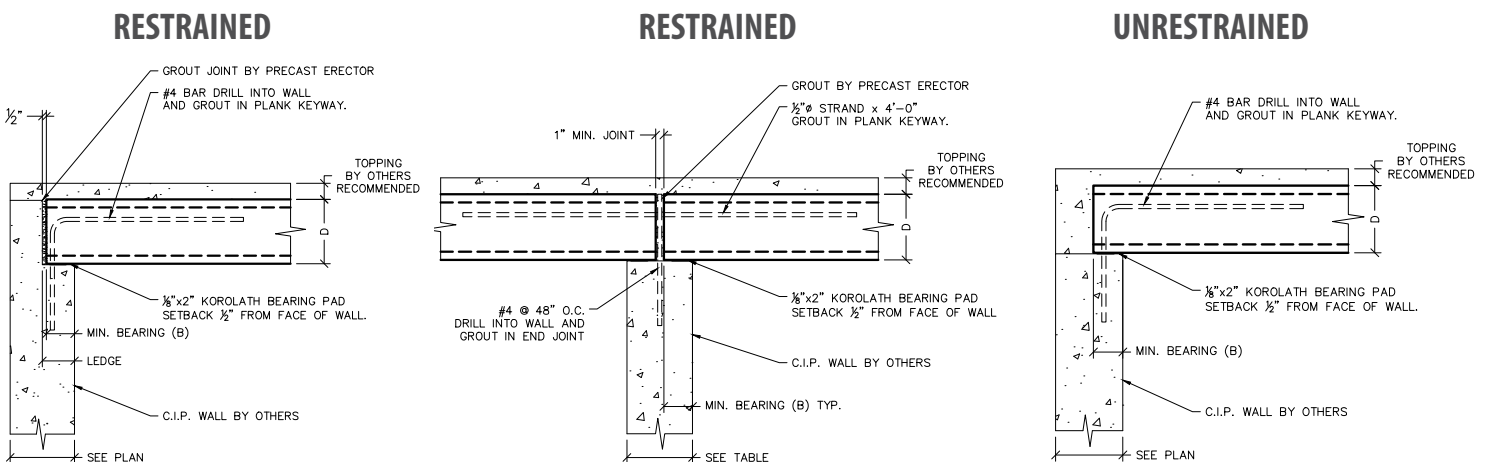


Fire Ratings in Precast Building Components

KP Design Notes I

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Fire Rating Specifications are an important part of any building construction project and are often dealt with during the beginning of the design process. They sometimes drive the materials selected for the structure, its compartments and exterior components for the need to protect the new structure in a fire event in an adjacent structure. Depending on the area of the project, there are a few different methods that can be utilized to determine the requirements. This is a brief overview of what is common in our area, however each project is unique and local codes should be consulted to ensure that the method selected is allowed. There is also a difference between Fire Rating and Fire Separation. A fire rating typically means the duration for which a passive fire protection system can withstand a standard fire resistance test. Fire Separation is a floor or wall having a fire rating required by appropriate authorities that acts as a barrier against the spread of fire within a building. Another factor in the rating of floors and roof members is the use of end conditions. Plank can be considered restrained by the Architect or Engineer of Record based on if thermal expansion is resisted by adjacent construction. Restrained bearing conditions offer longer fire endurances due to the restriction of the ends of the plank to move during an event.



Typical Methods to Determine Fire Endurance in Plank:

1. 2012 International Building Code (IBC) / 2012 Michigan Building Code (MBC)
2. Rational Design Method as defined by PCI MNL-124, "Design for Fire Resistance of Precast Concrete"
*Industry Preferred method of design.
3. Underwriters Laboratories (UL) Fire Resistive Ratings

International Building Code (IBC) / (MBC):

The IBC and the MBC are very easy to use for achieving a fire resistance. Since 2000, hollowcore plank utilized as a roof or floor member is required to have a fire rating. There are two requirements that have to be met in the code to achieve the desired fire endurance. They are the minimum total slab thickness and strand clear cover. Below is a step by step process on how Kerkstra Precast's hollowcore can perform under the IBC / MBC code.

| Kerkstra Precast Hollow Core Values | | | |
|-------------------------------------|--|---|----------------------|
| Hollowcore Cross Section | Cross-sectional Area, (in ²) | Equivalent Thickness, (in ² /in) | Strand Height, (in) |
| 8" Standard | 196 | 4.07 | 1.500 or 1.625 |
| 10" Standard | 244 | 5.08 | |
| 10" Heavy | 264 | 5.49 | |
| 12" Standard | 281 | 5.86 | |
| 16" Standard | 349 | 7.27 | |

1. Equivalent concrete thickness. All of Kerkstra Precast's hollowcore sections are made with a carbonate concrete type. This value can be found in the table above under "Equivalent Thickness". Equivalent thicknesses can be calculated by dividing the cross-sectional area by the nominal plank width (48"). To obtain a higher slab thickness, normal carbonate concrete field topping can be added to gain a higher total slab thickness. Other topping materials such as gypcrete can added to achieve a fire endurance using different tables.

Example: Slab thickness = 10" Hollowcore + 2" of topping = 5.08 in + 2.0 in = 7.08 in ≥ 6.6 in. Therefore, we meet the requirement for a 4 hour slab thickness, but the strand clear cover needs to be met too!

| Table 722.2.2.1 | | | | | |
|---------------------------------|--------------------------------|-----|-----|-----|-----|
| Minimum Slab Thickness (inches) | | | | | |
| Concrete Type | Fire-Resistance Rating (hours) | | | | |
| | 1 | 1.5 | 2 | 3 | 4 |
| Siliceous | 3.5 | 4.3 | 5 | 6.2 | 7 |
| Carbonate | 3.2 | 4 | 4.6 | 5 | 6.6 |
| Sand-lightweight | 2.7 | 3.3 | 3.8 | 4.6 | 5.4 |
| Lightweight | 2.5 | 3.1 | 3.6 | 4.4 | 5.1 |

IBC, 2012, pp. 172

2. Bottom strand clear cover over the prestressing strand is typically 1.5". If a higher endurance is required, the strand can be raised to give a clear cover of 1.625". Fire ratings utilizing this method are also impacted by the bearing condition, which can be restrained or unrestrained.

Example: Unrestrained hollowcore bays that requires a 4 hour rating. High strand cover = 1.625 in ≤ 2.25 in. Therefore, we only meet the requirement for a 2 hour cover thickness.

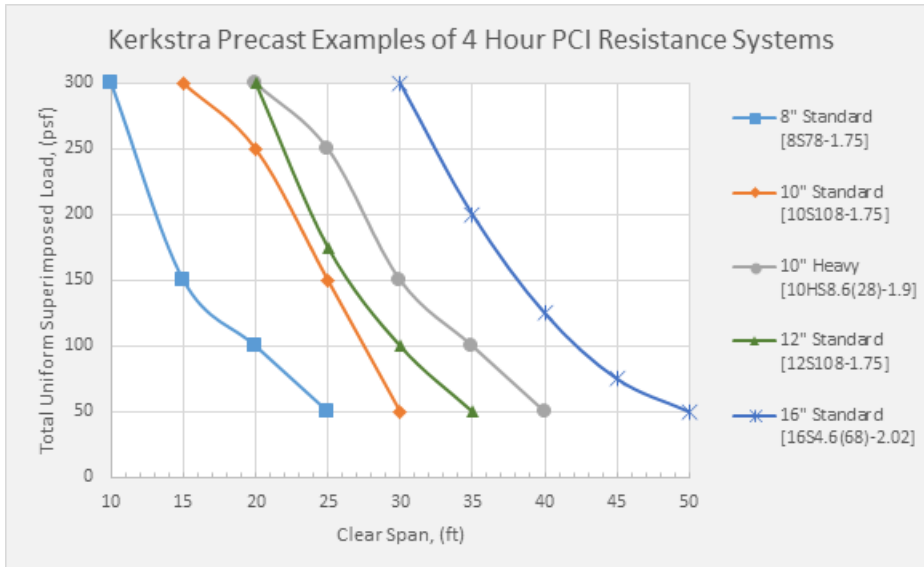
Example: Restrain every hollowcore bay that requires a 4 hour rating. Standard strand cover = 1.50 in ≥ 0.75 in. Therefore, we meet the requirement for a 4 hour cover thickness.

| Table 722.2.3 (2) | | | | | | | | | | |
|---|--------------------------------|------|------|------|------|--------------|-------|-------|-------|------|
| Cover Thickness for Prestressed Concrete Floor or Roof Slabs (inches) | | | | | | | | | | |
| Concrete Aggregate Type | Fire-Resistance Rating (hours) | | | | | | | | | |
| | Restrained | | | | | Unrestrained | | | | |
| | 1 | 1.5 | 2 | 3 | 4 | 1 | 1.5 | 2 | 3 | 4 |
| Siliceous | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 1.125 | 1.5 | 1.75 | 2.375 | 2.75 |
| Carbonate | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 1 | 1.375 | 1.625 | 2.125 | 2.25 |
| Sand-lightweight or lightweight | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 1 | 1.375 | 1.5 | 2 | 2.25 |

IBC, 2012, pp. 174

PCI Design by Rational Analysis

PCI MNL-124 allows a method defined as “rational analysis” for determining the fire rating of the precast and prestressed members. This is the preferred method for determining a fire rating of our precast cross sections for both walls and floor members. Actual practice has provided evidence that this method is conservative when compared to the IBC and UL methods. This method utilizes elevated temperatures in the prestressing strands to determine the moment capacities based on reduced capacities in the strand. Those reductions are compared to the moments required for service loads. Prestressing strand temperatures are based on the amount of cover provided and the standard fire exposure as defined by the time-temperature relationship provided in ASTM E-119. Unlike the IBC and UL rating, the PCI design does not require the distinction of restrained vs unrestrained. A few ways to gain higher fire endurance rating than that shown below is to raise the strain height, add composite topping, or use light weight aggregates.



*Openings and non-uniform loads will effect this design.

Underwriters Laboratories Fire Ratings

Prior to codes covering the ratings of floors and walls any member that carried a rating was actually tested in a laboratory and provided a UL number. This number was specific to the plank cross section, mix design and other properties of that section. Once a rating was achieved other cross sections can be evaluated by UL, compared to the tested section, and if warranted qualify for an existing UL number. The process of actually testing and receiving a UL number is extremely costly and time consuming. If a UL fire rating is required, then the answer is Kerkstra Precast’s 10” heavy section. Below is how to achieve different UL hours using this method.

| Kerkstra Precast’s UL J995 Fire Resistance Rating | | | |
|---|-------------------------|---------------------------|-------------------------|
| Hollowcore Section | Topping Thickness, (in) | Unrestrained Rating, (hr) | Restrained Rating, (hr) |
| 10” Heavy (J995) | 0 | 2 | 2 |
| | 1.5 | 2 | 3 |
| | 1.625 | 2 | 4 |

Additional Resources

Need help with design sources or fire rating design? Give us a call at 616-224-6176

Visit our website for technical resources <http://kerkstra.com/design>

Also see: 2012 International Building Code, 2012 Michigan Building Code, PCI MNL-120-10 Design Handbook, PCI Manual for the Design of Hollow Core Slabs Second Edition, PCI MNL-124-11 Design for Fire Resistance of Precast Prestressed Concrete.