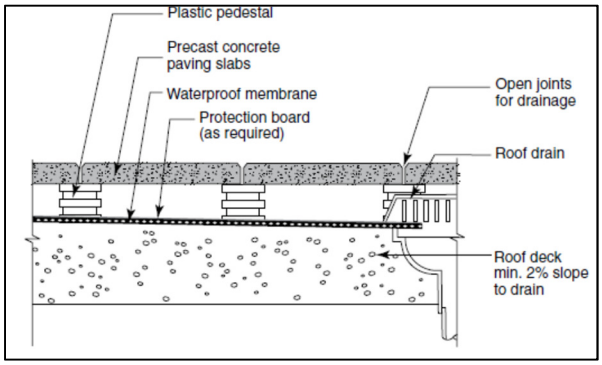
tech note

number L1

USE OF SEGMENTAL CONCRETE UNITS IN PEDESTAL APPLICATIONS
(Last Updated April 2020)

Pedestal applications involve suspending segmental concrete units over the roofing structure using plastic pedestals or polystyrene blocks (see graphic below). The concrete units protect the roofing materials from direct contact by foot traffic or equipment, shelter the roofing materials from severe climatic conditions, can be easily removed when access is required for repairs or maintenance to the roofing system, and are heavy enough (in most cases) to prevent shifting or uplift from high winds.



The purpose of this Tech Note is to assist design professionals in determining what segmental concrete products can be used in pedestal applications.

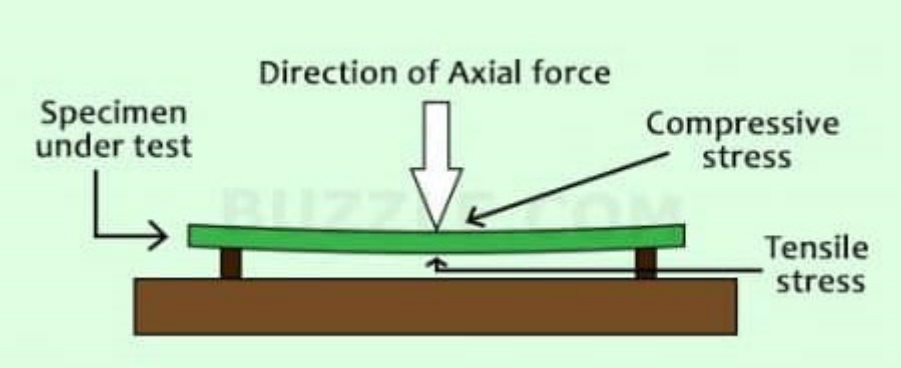
SEGMENTAL UNITS

In Canada, there are two primary segmental concrete unit categories – pavers and slabs. In simplest terms, pavers are generally small enough in size to be capable of installation with one hand while slabs are larger and therefore require two hands. CSA A231.19 further defines pavers and slabs as follows:

PAVER (CSA A231.2)	SLAB (CSA A231.1)
Face area ≤ 0.09 m^2	Face area > 0.09 m^2
Aspect ratio (length /thickness) ≤ 4	Aspect ratio (length /thickness) > 4
Thickness ≥ 60mm	Thickness ≥ 30mm
	Maximum length or width of 1,000mm
Average **compressive** strength ≥ 50 MPa No individual unit < 45 MPa	Average **flexural** strength ≥ 5.0 MPa No individual unit < 4.5 MPa
Freeze-thaw durability loss < 225g/m^2 at 28 cycles OR < 500g/m^2 at 49 cycles	Freeze-thaw durability loss < 225g/m^2 at 28 cycles OR < 500g/m^2 at 49 cycles
Length variation within -1mm to +2mm	Length variation within -1mm to +2mm
Width variation within -1mm to +2mm	Width variation within -1mm to +2mm
Height variation within +/- 3mm	Height variation within +/- 3mm
	Warpage < 2mm (3mm for units>450mm)

Units used in pedestal applications generally range from 254mm x 254mm (10" x 10") to 915mm x 915mm (36" x 36") in size, so fall in both the paver and slab classifications; however, material should be tested in accordance with CSA A231.1 for flexural (rather than compressive) strength since units are suspended between pedestals and therefore subject

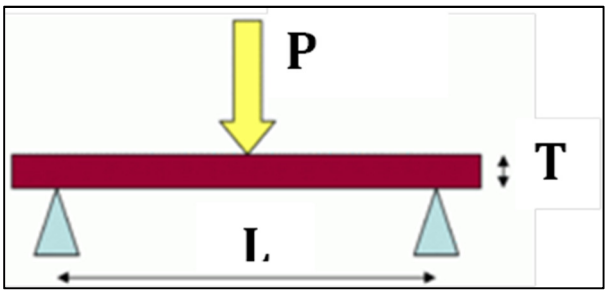
to both compressive and tensile stresses as shown below. Flexural strengths are typically only 10-15% of compressive strengths.



FLEXURAL ANALYSIS

The following formula is used to calculate the maximum load that can be applied to the middle of a suspended segmental concrete unit.

$$P = (2WRT^2)/(3L)$$

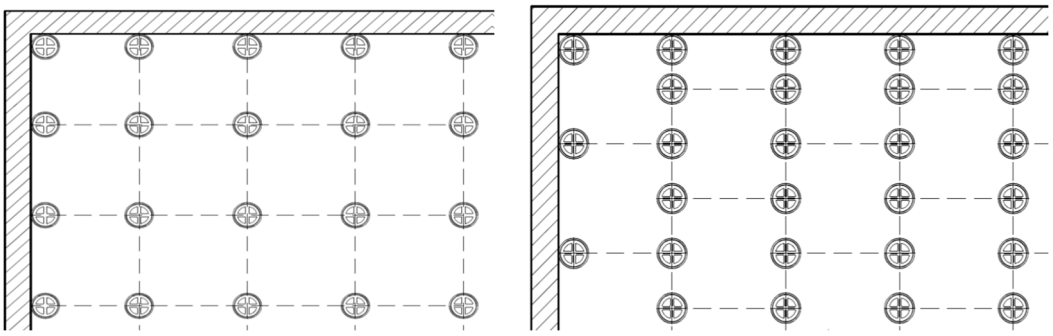


Where

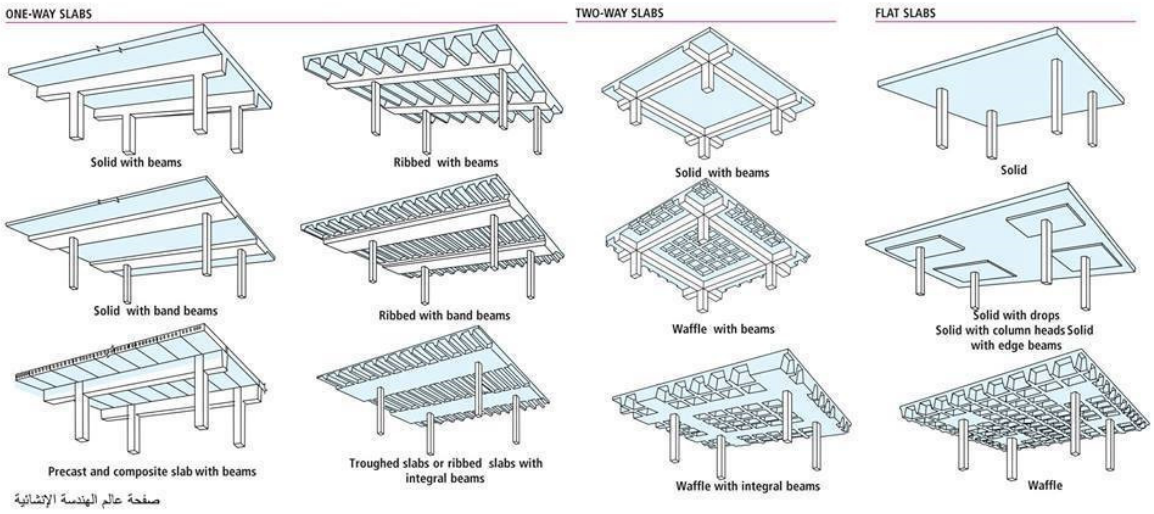
P = Maximum load (Newtons).
L = distance between pedestals (mm)
W = width of concrete unit perpendicular to L (mm)
T = thickness of paver (mm)
R = the minimum allowable flexural strength of the unit (4.5 MPa).

Some things to note:

1. Changes in length or width of the unit impact the maximum load the unit can handle in a directionally proportional manner; for example, if we reduce the width by 50% (from 600mm to 300mm as an example) we decrease the maximum load by 50%.
2. Changes in thickness impact the maximum load in a square function; for example, if we increase the thickness by 20% (from 50mm to 60mm as an example) we increase the maximum load by 44%. An increase of 100% (from 50 to 100mm) increases the maximum load by 300%.
3. Traditional pedestal spacing is one pedestals at each of the four corners of each unit similar to the stack bond pattern (left image below) as the number of pedestal is optimized (each unit is only supported at each of its corner); in this case L would be the longer of the length or width of the concrete unit. With a half running bond pattern (right image), additional pedestals are required as the corner points do not line up; L would then be the longest unsupported distance between pedestals (likely the distance across the top of the concrete unit).
4. Although pedestals can be added to reduce 'L' around the perimeter of the unit, the longest unsupported length remains the distance across the middle of the unit.
5. Adding a pedestal to the middle underside of each unit is sometimes done but cannot be properly modeled with the above equation; some form of computer generated modelling would be required (see Note to Reader).



NOTE TO READER – the above equation is based on the slab being fully suspended on both ends by metal rods similar to a one-way slab in building construction. In reality pedestal set products are suspended at the four corners, similar to a flat slab, but there are no simple calculations to model this scenario. As of the last update of this document, ICPI, to which Oaks is a member, is working on developing ways to properly model and evaluate pedestal set materials.



The following are failing loads for different individually packaged slab products available from Oaks based on the CSA minimum allowable strength of 4.5 MPa and being supported at the four corners.

1. Eterna 400x600 – 100mm: 20,000 N (2,040 kg or 4,487 lbs)
2. Rialto 16x24 – 80mm: 12,800 N (1,305 kg or 2,871 lbs)
3. Rialto 16x24 – 50mm: 5,000 N (510 kg or 1122 lbs)
4. Nueva XL Slab (600x900 – 60mm): 7,200 N (734 kg or 1,615 lbs)
5. Monterey 16x32 – 50mm: 3,750 N (382kg or 841 lbs).

DESIGN LOADS

Most producers "assume" that pedestal set applications are limited to rooftops (i.e. there is limited access to the area with the exception of maintenance staff). In fact, pedestal set can and has been used for everything up to and including on grade applications that handle occasional vehicular traffic; according to one colleague, the

main entrance to Toronto City Hall (shown below) is pedestal set and there are maintenance / snow plow equipment that drive over the area.

When evaluating the feasibility of using a product in a given application, two questions have to be asked: (A) what is the expected loading for the given application, and (B) what factor of safety should be applied.

Below is an excerpt from the Ontario Building Code on floors and roofs. Roof surfaces would be roof decks with limited access (maintenance staff); product needs to be able to support a specified concentrated load of 1.3 kN, or roughly the equivalent of 133 kg (291 lbs) point load. This load is intended to represent steel/hard wheel loads and/or point loads from repair/maintenance equipment. Classrooms would be the equivalent of rooftop or patio common spaces in condos (i.e. areas commonly used by tenants); the minimum specified concentrated load of 4.5 KN (459 kg / 1,010 lbs) accounts for point loads created by bench / table legs or items such as decorative planters. In extreme cases, such as rooftop or patio common space applications where there may be entertainment events being held (i.e. a stage is setup), or exercise areas are located (e.g. weight lifting equipment), the minimum specified concentrated load is 9 kN (918 kg / 2,020 lbs).

4.1.5.1. Loads Due to Use of Floors and Roofs

(1) Except as provided in Sentence (2), the specified live load on an area of floor or roof depends on the intended use and occupancy, and shall not be less than whichever of the following loads produces the most critical effect:

(a) the uniformly distributed load patterns listed in Article 4.1.5.3.,

(b) the loads due to the intended use and occupancy, or

(c) the concentrated loads listed in Article 4.1.5.9.

4.1.5.9. Concentrated Loads

(1) The specified live load due to possible concentrations of load resulting from the use of an area of floor or roof shall not be less than that listed in Table 4.1.5.9. applied over the loaded area noted in Table 4.1.5.9. and located so as to cause maximum effects, except that for occupancies not listed in Table 4.1.5.9., the concentrations of load shall be determined in accordance with Article 4.1.5.2.

Table 4.1.5.9.
Specified Concentrated Live Loads on an Area of Floor or Roof

Forming Part of Sentence 4.1.5.9.(1)

Item	Column 1 Area of Floor or Roof	Column 2 Minimum Specified Concentrated Load, kN	Column 3 Loaded Area, mm x mm
1.	Roof surfaces	1.3	200 x 200
2.	Floors of classrooms	4.5	750 x 750
3.	Floors of offices, manufacturing *buildings*, hospital wards and *stages*	9.0	750 x 750
4.	Floors and areas used by vehicles not exceeding 4000 kg gross weight	18	120 x 120
5.	Floors and areas used by vehicles exceeding 4000 kg but not exceeding 9000 kg gross weight	36	120 x 120
6.	Floors and areas used by vehicles exceeding 9000 kg gross weight	54	250 x 600
7.	Driveways and sidewalks over areaways and *basements*	54	250 x 600

In roof surface applications (1300 N), all of the products listed above exceed these requirements. The associated factors of safety range from 2.88 for the Monterey 16x32 to 15.4 for the Eterna 400x600.

For classrooms (4500N), all but the Monterey 16x32 would work. Factors of safety are:

1. Eterna 400x600 – 100mm: 4.44
2. Rialto 16x24 – 80mm: 2.84
3. Rialto 16x24 – 50mm: 1.11
4. Nueva XL Slab (600x900 – 60mm): 1.6

For office/stage applications (9000N), the factors of safety are

1. Eterna 400x600 – 100mm: 2.22
2. Rialto 16x24 – 80mm: 1.42