



*Technical Handbook and Product Catalog*

## **ACO DRAIN**

**Product Selection Guidelines**

**Product Details**

**Technical Design Support**



## The ACO Group



Founded in 1946, the ACO Group manufactures products for the building and construction industry.

Today, ACO employs over 3,800 people world-wide and has sales and manufacturing operations in more than 40 countries.

ACO is the world leader and pioneer of modular trench drain systems. ACO drainage systems are used in a variety of applications from domestic environments to airports. ACO products have been used at many prestigious locations, including Olympic stadiums, since 1972.

ACO USA was founded in 1978 and is America's foremost manufacturer of trench drainage products.





### Trench drain pioneers

*ACO Drain is the market leading, modular trench drain system and is manufactured at the company's modern manufacturing facilities in Ohio, Arizona and Iowa.*

*ACO Drain offers the most comprehensive range of trench drain solutions for every application. ACO Drain products come in a variety of widths, depths, and load ratings, with grates to suit.*

*In conjunction with a comprehensive, quality product range, ACO supports its business with extensive stocking distributors, technical sales support and world class customer service.*



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- 52 Polymer concrete catch basins
- 54 Accessories
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- 70 FastForm - FF300, FF600



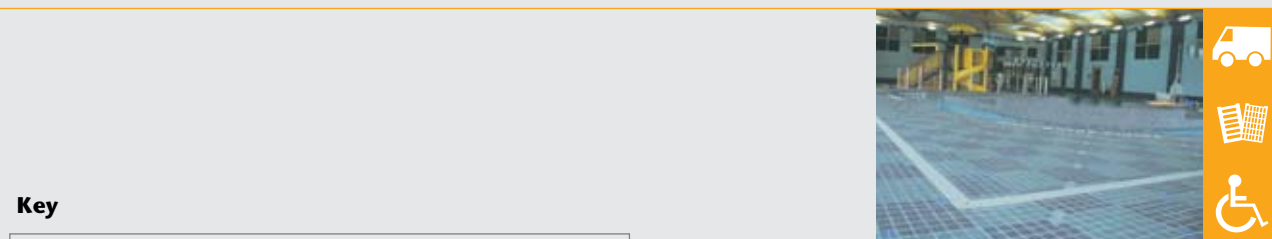
## Problem Solving Products

- 78 SlabDrain - H80, H100, H80K, H100K, H100SK
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**Key**

<i>Load class</i>	 up to C	 up to E	 up to F
<i>Grate options</i>	 Limited	 Small	 Wide
<i>ADA compliance</i>	 ADA grate(s) available		

## Options for dealing with surface drainage

Surface drainage is important.

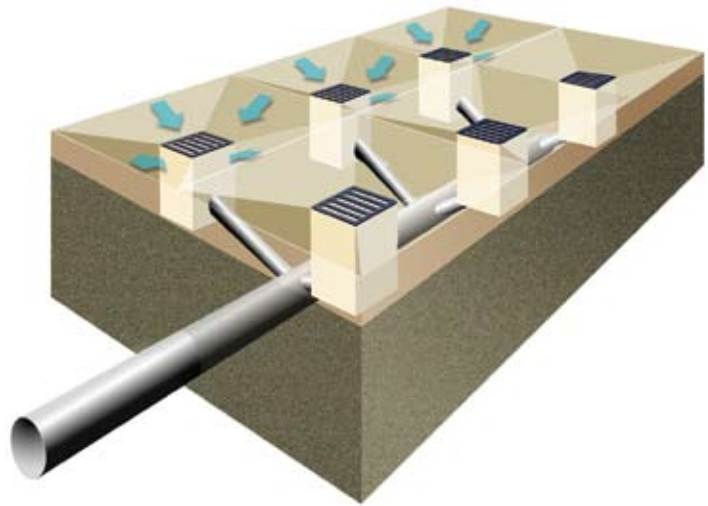
Whether frequent light rainfall or occasional heavy downpours, surface drainage is necessary. It prevents damage to pavement or property, and reduces safety hazards caused by ponding. Surface drainage is designed to:

- Reduce ponding (standing water)
- Reduce slip hazards and subsequent injury
- Protect, and extend, life of paved surfaces
- Protect property from flood damage
- Reduce inconvenience to public users
- Reduce hydroplaning on roads

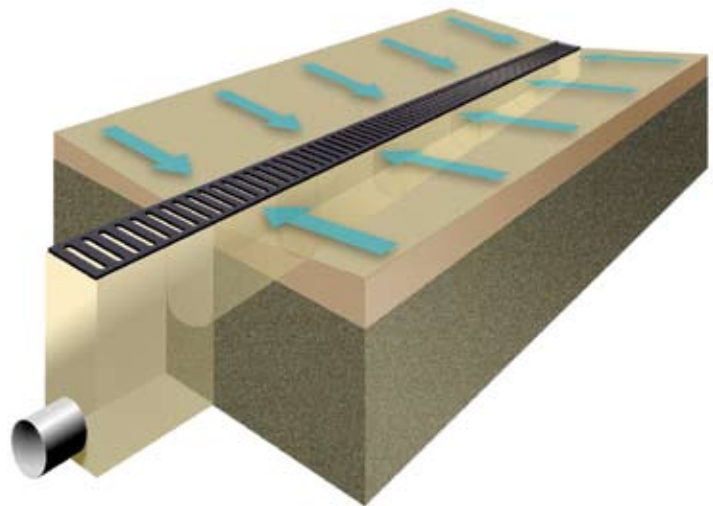
### Options available:

- Ignore it
- Open swale
- Catch basins
- Trench drains

### Catch basin drainage



### Trench drainage



For solid pavements the first two are not ideal. Catch basins or trench drains are the most viable solutions.

### 2004 Master Format Codes

Trench drains and grates originally fell into Divisions 2, 3, 5 and 15.

With the expanded Master Format categories they now fall into the following divisions:

- 03 48 00 - Precast Concrete Specialties
- 05 53 00 - Metal Gratings
- 22 14 00 - Facility Storm Drainage
- 33 44 00 - Storm Drainage Utilities





- Uneven, undulating appearance
- Complex, multiple grades to design and construct
- Deeper ground excavation due to pipe depths
- Higher risk of ponding
- Pipes prone to blocking and failure
- Maintenance can be difficult and costly as access to pipe work is restricted
- Possible interference with other services, e.g., electrical, sewage, etc.

- Neat linear appearance
- Simple grades to design and construct
- Easy to install - shallower excavation and easy grading of pavement
- Continuously intercepts water and provides superior drainage
- Minimal underground pipes - less excavation and site disturbance
- Maintenance is quick and easy as trench is at the surface and easier to access



## Sustainable drainage



Sustainable drainage is an element of the 'Hydrological Cycle'. It is the collection of rainwater, its treatment and, ultimately, its reuse.

The process involves capturing water run-off, that may or may not contain pollutants, so it can be dealt with in a controlled manner. The water can then be treated, stored for future use, or transported to receiving waterways. This transfer of water should come at low cost, and cause minimal damage and danger to the environment.

Surface drainage can be used where rainwater has collected on paved areas for the 'capture' part of this process.

Trench drains are ideal for the capture and collection of storm water run-off. They form a barrier to prevent rainwater run-off flowing onto the soft landscaping where collection is more difficult. This is of particular importance if the risk of contamination is high, such as highway and gas station applications.

ACO provides a wide range of trench drains to meet the hydraulic needs of any sustainable drainage design.



## LEED

'Leadership in Energy and Environmental Design'; provides a green building rating system. Principles have been applied to commercial and institutional projects, schools, multi-unit residential buildings, manufacturing plants, laboratories and other building types.

Areas where the use of trench drainage may assist in the assignment of credits include:

### SUSTAINABLE SITES

#### Credit 5.1 - Site Development

Compared to catch basins, trench drains require minimal excavation; reducing site disruption.

#### 6.1 & 6.2 - Stormwater Design

Trench drains capture run-off, enabling treatment which prevents pollution of receiving streams. Run-off can also be collected for non-potable uses such as irrigation.

### WATER EFFICIENCY

#### Credit 1.1 & 1.2 Water Efficient Landscaping

Reduce or eliminate use of potable water for irrigation by capturing rainwater in trench drains and storing for future irrigation use.

#### Credit 2 - Innovative Wastewater Technologies

Using captured rainwater for building sewage conveyance.

#### Credit 3.1 & 3.2 - Water Use Reduction

Capturing and re-using stormwater for non-potable applications.

### MATERIALS & RESOURCES

**Credit 2.1 & 2.2 - Construction Waste Management.** Reduction of debris going to landfills and incinerators. Compared to area drains, trench drains require minimal excavation; reducing site waste/debris.

Compared to polystyrene formers, FastForm cardboard formers are easier to dispose of.

Go to [www.usgbc.org](http://www.usgbc.org) for full details.



### Choosing the correct trench drain

When choosing a trench drain, the following factors should be considered:

Hydraulic Performance - how much liquid is to be collected and removed.

Application - there are a number of issues relating to where the drain is used.

These factors should be addressed regardless of whether a modular channel system or cast-in-place is used.

#### 1. Hydraulic performance

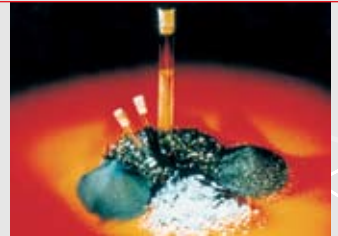


#### 2. Application

##### 2a) Loading



##### 2b) Durability



##### 2c) User requirements



The volume of liquid the trench drain collects and carries in a given time period.

- Important factors include:**
- Width and length of catchment area
  - Rainfall intensity
  - Grade of pavement
  - Outlet size and location

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Loading refers to any foot or vehicular traffic being applied to the trench and grate.

Load standards are a tool to enable comparison of products and provide a measurement scale.

- Important factors include:**
- Weight
  - Wheel type - solid or pneumatic
  - Traffic patterns - traffic speed, frequency, braking, turning, etc.

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To ensure long life, products must be carefully selected and installed correctly. An investigation of the application's environment is recommended to identify any chemicals or other corrosive elements that may affect material choices. Typical trench materials include polymer concrete, fiberglass and HDPE plastic.

- Important factors include:**
- Trench material
  - Grate material
  - Edge protection
  - Chemical resistance
  - Installation

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There is often more than one channel, grate and locking option that will meet hydraulic, loading and chemical resistance needs. User requirements are project specific and are determined by either design preference or legal obligations.

- Important factors include:**
- Aesthetics
  - Legislative requirements - e.g., ADA compliance
  - User safety - e.g., 'Heelsafe', bicycle safe
  - Security - grate locking options

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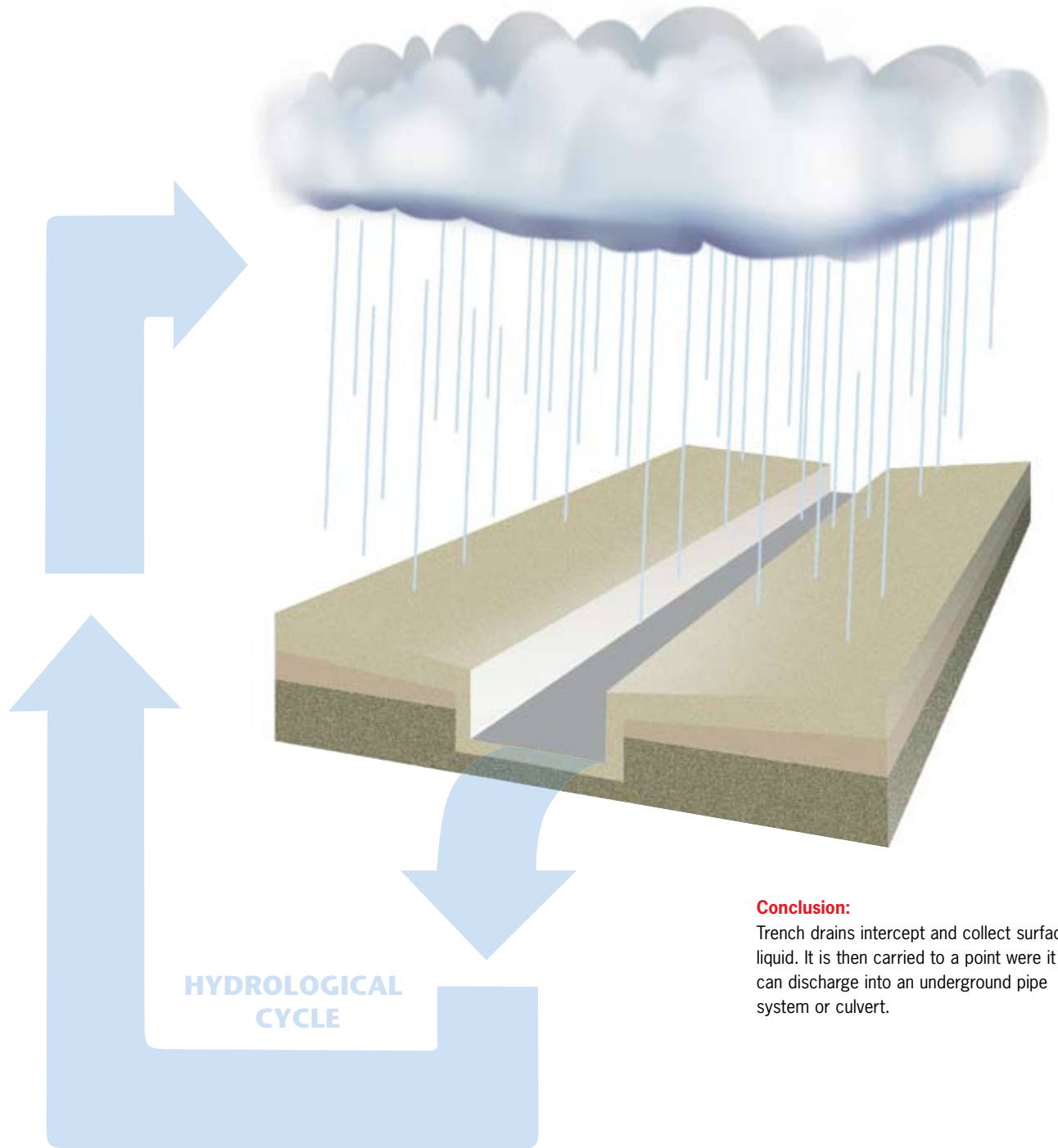


# 1. Hydraulic Performance

## Modeling hydraulic performance of trench drains

**Assumption:**

Rainwater falls over an area and runs towards, and collects at, any low point.

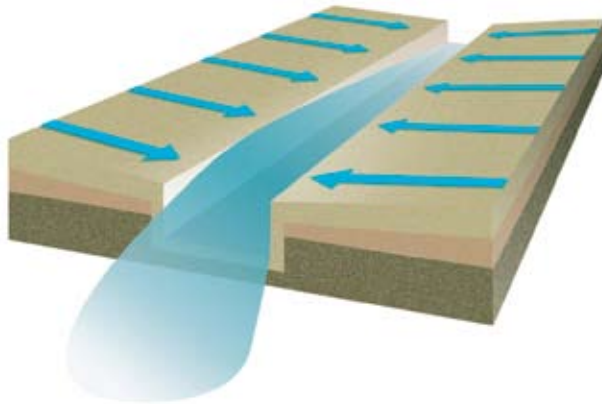


**Conclusion:**

Trench drains intercept and collect surface liquid. It is then carried to a point where it can discharge into an underground pipe system or culvert.

**Non-uniform flow (Spatially Varied Flow)**

$$\frac{dy}{dx} = \frac{S_o - S_f - 2\alpha Qq / g A^2}{1 - \alpha Q / g A^2 D}$$



✓ - accurate

Non-uniform flow accounts for liquid being carried in a trench **plus** the constant addition of liquid collected through the grates along the trench run - lateral intake.

A characteristic of non-uniform flow is that liquid velocity and height change at successive cross sections along the trench.

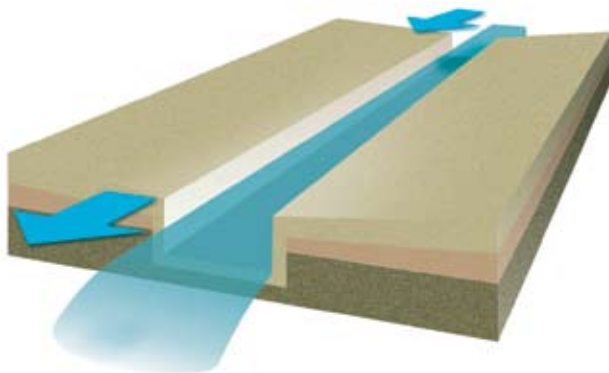
To correctly model this situation, differential calculus is required; usually computer modeling is needed.

As a result of empirical testing, ACO has developed a computer program, 'Hydro', that models trench hydraulics.

*ACO provides a complimentary service for trench hydraulics. See page 110 for details.*

**Steady, uniform flow (Manning's Theory)**

$$Q = A \times V \left( \frac{1}{n} \times m^{2/3} \times s^{1/2} \right)$$



✗ - inaccurate

A commonly used method of calculating trench hydraulics involves the use of equations for steady uniform flow.

This approach is better suited for pipe design where liquid velocity and height remain constant along the pipe.

**No** allowance is made for lateral intake.

Steady, uniform flow can be used in culvert (open top) design for dams or irrigation trenches. These culverts are used to carry liquids from one area to another and **do not** account for lateral intake of liquids.

# 1. Hydraulic Performance

## Catchment hydraulics - calculating run-off

To calculate the correct size of trench drain, catchment run-off must be calculated.

- Catchment area - length x width of pavement (ft) ..... **A** x **B**
- Rainfall intensity in inches per hour ..... **C**

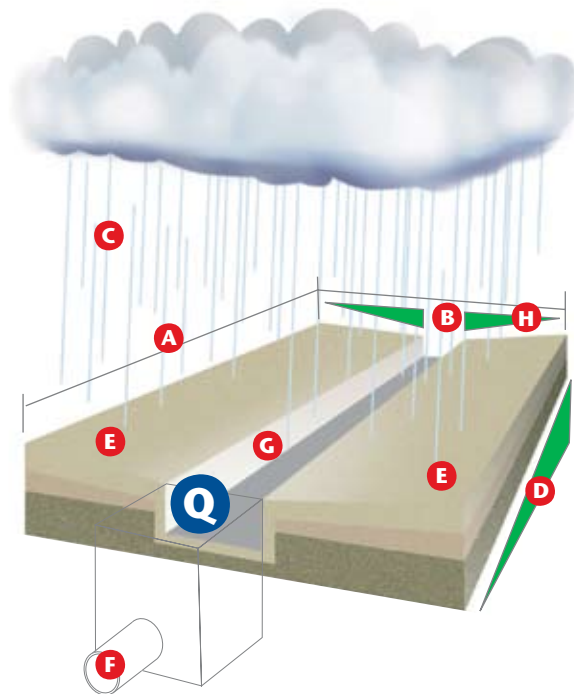
Once catchment run-off 'Q' is calculated, other inflows, e.g., down spouts, can be added.

[www.acousa.com/choosing\\_trench.htm](http://www.acousa.com/choosing_trench.htm)  
has a link to the US government rainfall frequency atlas

Other factors that affect how much liquid reaches the trench and how quickly;

- Ground fall percentage ..... **D**
- Pavement material - some materials absorb liquids, e.g., brick pavers ..... **E**
- Position and size of outlet pipe ..... **F**
- Surface roughness of trench material. Manning's coefficient of roughness figures are available ..... **G**
- Angle of approach to trench - this can affect grate hydraulics (steep slopes may cause bypass) ..... **H**

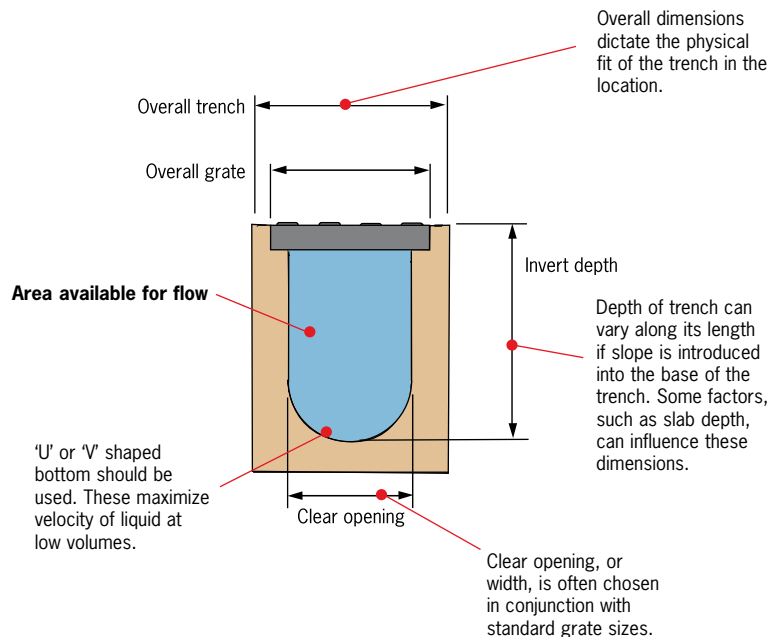
$$Q \text{ (GPM)} = \frac{\text{Area (AxB)} \times \text{Rainfall intensity (C)}}{60(\text{minutes}) \times 1.6(\text{Conversion to gallons})}$$



## Determining trench size

Once run-off **Q** is calculated, it is used with the other factors above to determine the correct size of trench. The trench size is dictated by the clear opening and invert depth - changing either or both of these will create a smaller or larger 'flow area'.

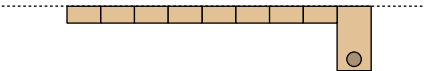
- Clear opening of trench is the normal specified dimension, e.g., 4", 8", etc.
- Overall grate and outside trench dimensions are misleading. Some trench drain companies promote these sizes to mislead specifiers and installers, e.g., overall trench dimension of 6". Usually clear opening will be approx. 4"- **this is the dimension available for hydraulic flow, not 6"**.



**Factors affecting trench run hydraulics**

**D Ground fall or slope**

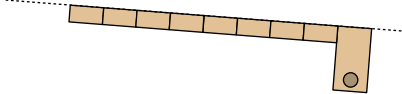
**Neutral invert, zero ground fall**



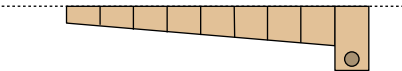
Slope increases the velocity of liquid within the trench drain and improves hydraulic efficiency. Slope can be introduced by:

1. Existing pavement with natural fall.
2. Introducing slope along the base of the trench run.
3. Combination of both.
4. Negative fall.

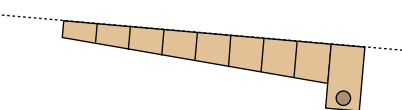
**1. Neutral invert, positive ground fall**



**2. Sloped invert, zero ground fall**



**3. Sloped invert, positive ground fall**

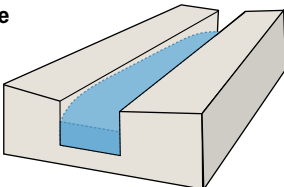


**Effect of slope on trench hydraulic performance**

**Non-uniform flow**

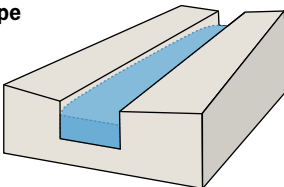
Accurately accounts for affect of slope and run length. Models the accurate hydraulic performance of trench. Allows correct size of trench drain to be used.

**Zero slope**



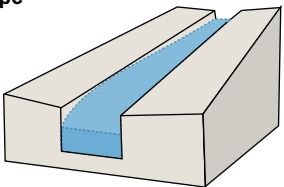
Slope is part of the equation - but not as a multiplier. Trench size is accurately calculated.

**Small slope**



Slope is part of the equation - but not as a multiplier. Trench size is accurately calculated.

**Large slope**



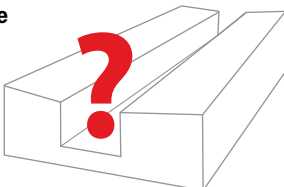
Slope is part of the equation - but not as a multiplier. Trench size is accurately calculated.

**Steady uniform flow**

Uses Area x Velocity to estimate flow capacity. When there is little or minimal slope, velocity tends towards zero, and trench performance is under estimated.

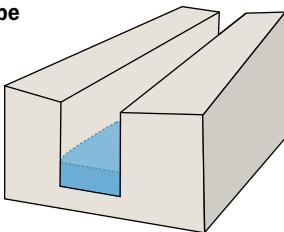
When there is significant slope, steady uniform flow over estimates the hydraulic performance of the trench drain.

**Zero slope**



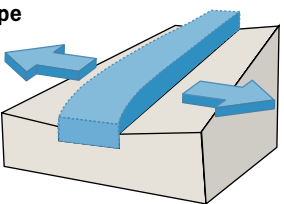
Slope is a multiplier in the equation ( $Q=A \times (1/n \times m^{2/3} \times s^{1/2})$ ). Velocity is calculated as zero and trench size **cannot** be calculated.

**Small slope**



When slope is small, velocity is calculated as minimal. Trench size is over sized - **resulting in a larger, more costly trench.**

**Large slope**



When slope is large, velocity is also calculated as high. Trench size is under sized - **resulting in flooding.**

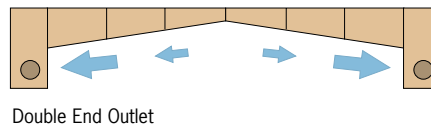
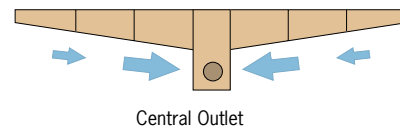
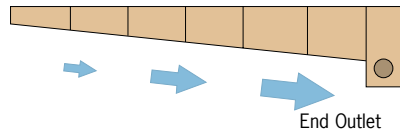
## Factors affecting trench run hydraulics

### F Position and size of outlet pipe

A trench drain is ultimately connected to the underground pipe system. If the trench drain is designed with an end outlet, the water builds up along the trench and may flood before reaching the outlet. Alternatively a larger and more costly trench drain and/or more outlets are required to prevent flooding.

If there is zero ground slope and underground pipe work position is not a factor, the trench drain can be designed with a central outlet. Run lengths to the outlet are shorter and less likely to exceed capacity and flood. This allows a smaller, more economic trench drain and/or fewer outlets to drain the same volume.

If there is a central high point, double end outlets offer maximum continuous slope and utilize the natural ground slope towards the outlets.



### Size and type of outlet

In modeling hydraulic performance of trench drains, the assumption often made is that the outlet is not a restricting factor. Designers should ensure the outlet or subsequent pipe work is not undersized and acts as a 'throttle' to the trench drain.



**End outlet** - pipe connected horizontally at the end of the trench. Offers lowest outlet capacity.



**Bottom outlet** - pipe connected vertically out of the bottom of the trench. Offers improved outlet capacity due to gravity.



**In-line catch basin** - usually same width as trench, but deeper. Allows use of trash bucket to collect debris. Offers superior outlet capacity as larger pipes can be connected and increased depth gives significant head of water pressure.



**Catch basin** - large basin wider and deeper than trench. Allows use of trash bucket to collect debris. Offers best outlet capacity as largest pipes can be used and increased depth gives significant head of water pressure.

**G Angle of approach to trench**

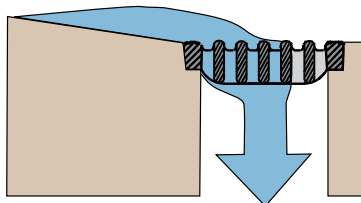
**Grate hydraulics**

Usually the trench drain reaches hydraulic capacity **before** grate intake hydraulics affect performance. Occasionally grate hydraulics become the determining factor, especially with restricted openings, e.g., perforated grates.

To calculate grate hydraulics, the following information is required;

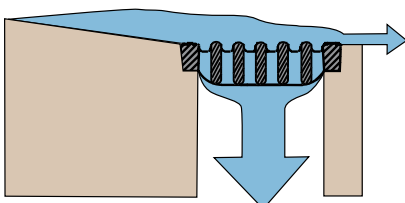
- Trench length
- Width of catchment area each side of trench
- Pavement type
- Geometry of catchment area including slope approaching the grate

**Lateral inflow from surrounding pavement**



**100% Capture**  
All liquid flowing through grate

**Bypass**



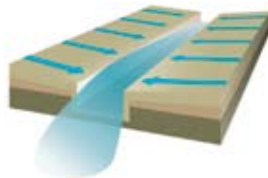
**Less than 100% Capture**  
Not all liquid flowing through grate, bypass has occurred. Could be due to not enough grate open area, too much liquid, or too much slope perpendicular to grate

*ACO provides a complimentary service for grate intake hydraulics. See page 111 for details.*

**Hydraulic summary**

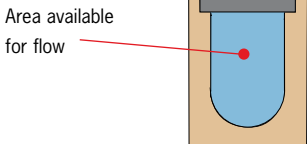
Key factors to consider:

**1. Lateral intake**



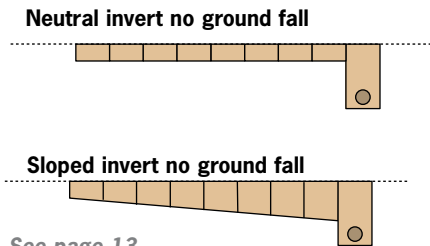
See page 11

**2. Clear opening**



See page 12

**3. Slope**



See page 13

**4. Outlet**



See page 14

## 2.a Application - Loading

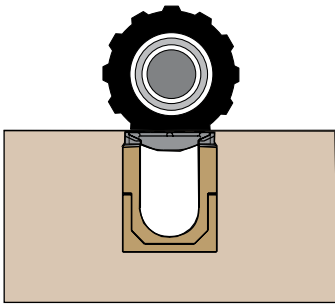
### Factors affecting loading

Loading is the type of traffic the trench drain is exposed to. Traffic refers to any foot or vehicular traffic moving over the trench drain.

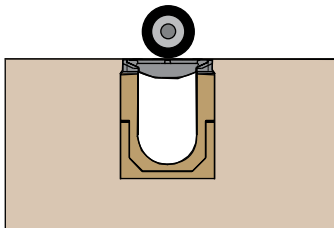
The following should be considered:

#### Wheel loads

- Weight of vehicle/cart and its typical load
- Type of wheels - solid or pneumatic tires
- Will other unusual vehicles, e.g., dollies/dumpsters, be going over the trench?



Larger and/or pneumatic tires spread the load over a larger contact area - exerting a low stress (psi).

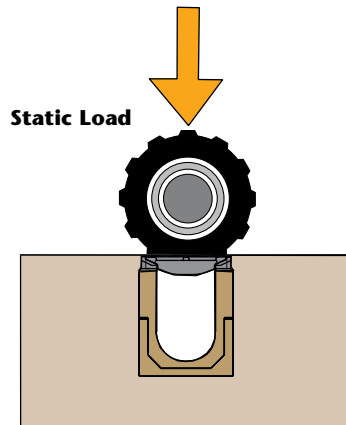


Small and/or solid tires concentrate the load onto a small contact area, exerting a high stress (psi).

A grate and/or system with a higher load rating will be required in these applications.

#### Static loads

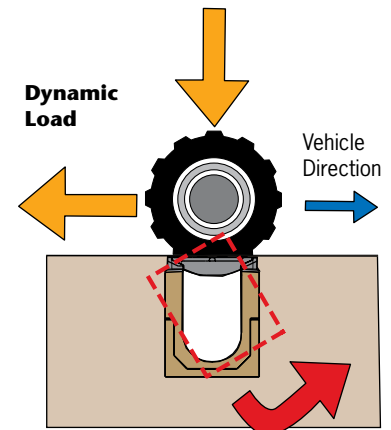
- Load/weight applied vertically onto the trench, no other movement.



Static loads are used when load testing a grate, but poorly simulate real traffic scenarios. They provide a measuring scale to rate loadings of grate/trench drain.

#### Dynamic loads

- Will vehicles be travelling across or along the trench?
- Will traffic be braking or turning on the trench?
- Frequency of traffic?
- Speed of traffic?
- Is trench located at bottom of a ramp?



Moving traffic creates a dynamic load. This movement tries to twist the trench drain out of position. Trench body, grate loading, installation, and locking mechanisms, are all important factors to consider when addressing dynamic loads.

The more movement (turning and/or braking) and the faster the traffic, the greater the dynamic load.



## Load Standards

There are a number of American standards that make reference to grate loading. There is no current standard that specifically deals with trench drains of different widths.

Common standards in North America:

- **ASME: A112.6.3 - 2001**  
*Plumbing standard relating to internal floor drains. Test blocks are 3.5" diameter and grates are rated up to 10,000lbs - 1,039psi.*
- **AASHTO Standard Specification for Highways Bridges**  
*Standard relating to design for bridges. Loadings are dealt with by wheel 'footprints' and axle ratings. No specification is given for measurement of the performance of trench drains. General specifications relate to vehicle loading up to HS25. Maximum truck weight 90,000lbs - 3 axles.*  
  
*AASHTO: M306 - 05 acknowledges the addition of HS25 as referenced by some trench drain manufacturers.*
- **AASHTO: M306 - 05 Drainage Structure Castings**  
*Standard relating to castings used in roadways. Test blocks are 9" x 9" and maximum rating is 40,000lbs - 494psi*
- **A-A60005 Federal Specifications** (Previously RR-F-621E)  
*General federal product specification aimed at manhole covers and catch basin grates. Test blocks are 9" x 9" and maximum rating is 25,000lbs - 309psi*
- **FAA AC: 150/5370-10 - Item D-751**  
*Airport standard that covers manholes, catch basins and inspection holes. No measurement or specification given for testing.*
- **FAA: 150/5320-5B & 6D**  
*Standard relating to airport drainage and pavement designs. Load tests up to 100,000lbs, but no specific test block size specified.*
- **'200,000lb proof load'**  
*The lack of a very heavy duty test standard created the need for a 'line of measurement'. Manufacturers of cast iron access covers used the structure of the RR-F-621E standard with 9" x 9" test block but promoted the use of a 200,000lbs proof load - 2,469psi. Although no independent standard refers to this measure, it has become widely accepted as a 'line of measurement' for very heavy duty loadings.*

Most of these standards refer to catch basin or cast-in-place grates, which are larger than most trench drain grates.

## DIN 19580 / EN 1433

The only standard written specifically for trench drains, and internationally recognized, is **DIN 19580**.

DIN 19580 accounts for different widths of grates. For trench drains less than 8" wide, the required test block for load testing is 10" long by 3" wide. For trench drains 8" and 12" wide, the test block is 10" by 6"; for trench drains over 12", the test block is 10" diameter. This ensures that the full force of the test load is directed onto the grate.

DIN 19580 is being superseded by **EN 1433**. EN 1433 tests products in exactly the same method as DIN 19580 with the same load categories, A - F up to 202,320lbs - 4,182psi.

As with DIN 19580, EN 1433 offers testing methods for both the complete trench drain and individual grates. It accounts for both proof loading and catastrophic failure.

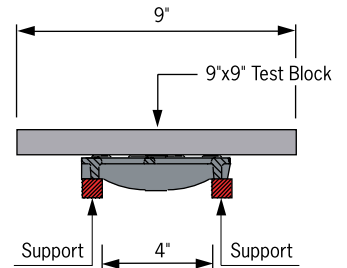
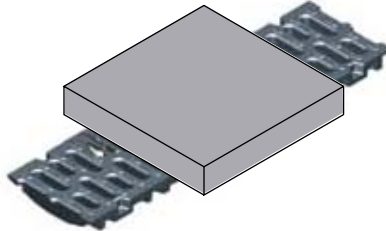


## 2.a Application - Loading

### Test blocks

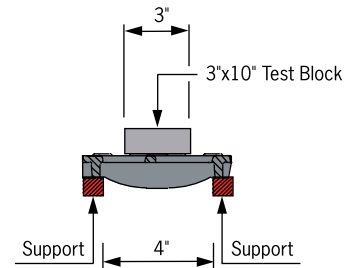
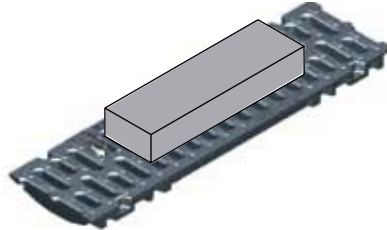
#### Load test using oversize test block

Test load applied to a grate to suit a 4" clear opening trench through a 9" x 9" test block. The grate is not being tested - the load is taken by the supports rather than the grate. Any results from this type of grate test are questionable.



#### DIN 19580 / EN 1433 load test - with relevant test block

A 3" x 10" test block applied to a similar grate - the full test load is being applied to the grate giving a meaningful result.

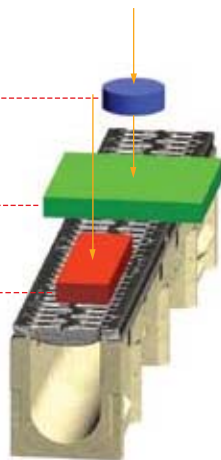


The diagram below shows test block sizes required by the various load standards available in North America, relative to a 4", 8" and 12" trench. To be a reliable grate test, the test block should fit inside the internal width, otherwise the load is transferred onto the grate supports.

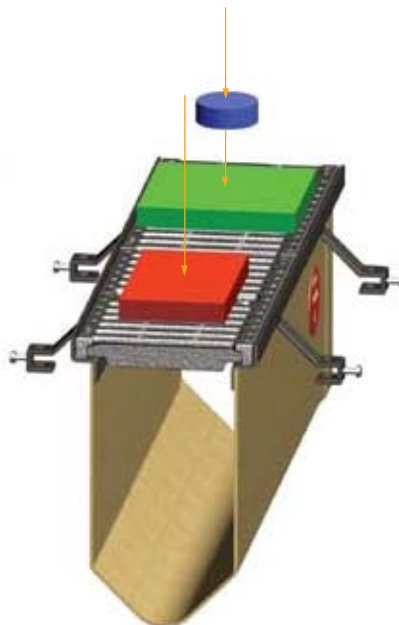
ASME A112.6.3 - 2001

200,000lb Proof Load  
AASHTO M306-05  
A-A60005

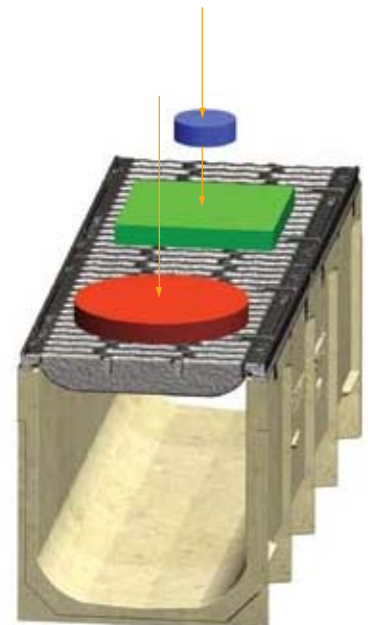
DIN 19580 /  
EN 1433



4" channel









8" channel



12" channel



## DIN 19580/EN 1433 table of load classification

						
	Load Class <b>A</b>	Load Class <b>B</b>	Load Class <b>C</b>	Load Class <b>D</b>	Load Class <b>E</b>	Load Class <b>F</b>
	3,372lbs 15kN	28,100lbs 125kN	56,200lbs 250kN	89,920lbs 400kN	134,800lbs 600kN	202,320lbs 900kN
<b>PSI rating</b>						
Trench width						
4"	70psi	581psi	1,162psi	1,859psi	2,788psi	4,182psi
8" to 12"	58psi	484psi	968psi	1,549psi	2,323psi	3,485psi
Over 12"	44psi	369psi	739psi	1,182psi	1,773psi	2,659psi
<b>Typical uses</b>						
	Residential and light pedestrian traffic	Sidewalks and small private parking lots	Parking lots and general commercial use	Trafficked sections of roads and highways	Industrial areas, gas stations and light commercial forklifts	Aircraft runways, docks, heavy fork trucks and heavy wheel loads

### DIN 19580 / EN 1433 (max)

Over 12" - 2,659psi

8"-12" - 3,485psi

4" - 4,182psi

### 200,000lb proof load

2,469psi

### ASME: A112.6.3 - 2001

1,039psi

### AASHTO:M306-05

494psi

### AASHTO HS20/HS25

888psi 1,111psi

### A-A60005

ACO believes DIN 19580 / EN 1433 is currently the most recognized, independent standard to measure product performance.

**CAUTION:** Check if a stated load class relates to a specific standard.

## 2.a Application - Loading



### Load Class A 3,372lbs - 15kN

Residential and light pedestrian traffic



### Load Class B 28,100lbs - 125kN

Sidewalks and small private parking lots



### Load Class C 56,200lbs - 250kN

Parking lots and general commercial areas



### Load Class D 89,920lbs - 400kN

Trafficked sections of roads and highways



### Load Class E 134,800lbs - 600kN

Industrial areas, gas stations and light commercial forklifts



### Load Class F 202,320lbs - 900kN

Aircraft runways, docks, heavy fork trucks and heavy wheel loads



SPEED  
LIMIT  
20

8 North  
New York  
EXIT ONLY

## 2.b Application - Durability

### Material properties

Modular trench drain systems are generally manufactured from either polymer concrete, fiberglass or HDPE (High Density Polyethylene).

ACO Drain commercial grade trench systems are manufactured from either polymer concrete or fiberglass. Other materials do not meet the compressive strength and thermal expansion properties required in commercial and industrial projects.

ACO only uses HDPE as a trench material for residential applications.

### Polymer concrete

Polymer concrete is a versatile composite material produced by mixing mineral aggregates with a resin binding agent. The finished material has excellent mechanical and thermal properties and offers good corrosion resistance to many chemicals. A maximum working temperature of 180°F (82°C) is recommended.

For increased chemical resistance, Vinyl ester polymer concrete is available. This consists of Vinyl ester resin binder with superior silica aggregate fillers.

See *chemical resistance chart page 115*.

Due to their structural rigidity, polymer concrete trench drains can be used in a variety of pavement types such as concrete, asphalt and brick pavers.



Resin



Hardener



Aggregate



Sand

### Fiberglass

Fiberglass uses similar resin binding agents to those used for polymer concrete, but glass mat and fibers are used instead of mineral aggregates to provide a robust flexible material.

Fiberglass trench drains are designed to be fully encased in concrete.

### Cement concrete

Cement concrete is Portland cement mixed with aggregates. Generally used for large cast-in-place slab applications, where mass is required for structural rigidity.

### HDPE (Plastic)

High Density Polyethylene (HDPE) is the most common plastic used in trench drains. HDPE is a readily available, economical material that is easy to mold. HDPE has poor thermal properties. A trench drain of 100ft in length with an ambient temperature change of 75°F can expand (or contract) up to 9.9 inches more than the surrounding concrete slab. The concrete surround will only change minimally and cause the trench to buckle or pull away from the concrete.

### Grates

Grates are manufactured from a variety of materials. The most common are ductile iron, mild steel, stainless steel and plastic.

Grates need better tensile properties than the trench body to withstand flexural loads. Grates can be changed or easily replaced after installation, unlike the trench drain body.

### Mechanical properties

#### Compressive strength

The trench body is subject to compressive loads in use and needs to withstand the specified load.

#### Flexural strength

Affects site handling and when trench body is in areas where encasement and soils are suspect.

#### Tensile strength

Not generally required in trench bodies, but relevant to grates. Used as material measurement.

### Thermal properties

#### Water absorption

The trench is designed to carry and collect liquids without contaminating surrounding soil/encasement.

#### Freeze-thaw

Inability to withstand freeze-thaw cycles causes surface spalling and leads ultimately to trench failure.

#### Coefficient of expansion/contraction

Excessive movement between trench and encasement materials creates unwanted stresses which may lead to failure.

#### Water vapor transmission

WVT is measurement of water vapor flow through a material. Passage of water vapor may be critical in some instances.

### Surface properties

#### Surface burning

Trench systems are often used around gas stations, chemical processing and interior applications and may be subject to fire; they should be non-flammable and not give off fumes or smoke.

#### Weathering

The majority of trench drains are used in exterior applications. Ability to withstand adverse weather will ensure long service life (erosion, UV degradation etc).

#### Roughness Coefficient (Manning's)

Any degree of friction will affect liquid flow to an extent, therefore the lowest value is desirable.

#### Chemical resistance

Trench may be used for liquids other than water and in such circumstances, needs to be resistant to a variety of mediums. See page 115 for details.

**Key:** - Good - Acceptable - Poor



Cement Concrete	Polymer Concrete	Fiberglass	HDPE
4,500psi C-39	14,000psi C-579	24,400psi D-695	8,450psi D-695
587psi C-78	4,000psi C-580	9,943psi D-790	2,224psi D-790
419psi <sup>a</sup>	3,000psi C-307	7,378psi D-638	1,993psi D-638
<b>+5.00% C-97</b>	<b>+0.07% C-97</b>	<b>+0.33% D-570</b>	<b>+0.31% D-570</b>
300 cycles maintain 80% structural integrity	300 cycles modulus of elasticity 95.1% C666	223 cycles modulus of elasticity 89.5% C666	223 cycles FAILED modulus of elasticity test C666
6.5 x 10 <sup>-6</sup> per °F E831	25.30 x 10 <sup>-6</sup> per °F E831	55.32 x 10 <sup>-6</sup> per °F E831	116.50 x 10 <sup>-6</sup> per °F E831
See water absorption test	WVT - 0.0364g/m <sup>2</sup> 1,592hrs E96	WVT - 0.1085g/m <sup>2</sup> 1,592hrs E96	WVT - 0.1392g/m <sup>2</sup> 1,592hrs E96
7 rating E119	Flame spread : 0 Smoke density : 5 E84	After flame time : 216 seconds - fail UL-94	After flame time : 390 seconds - fail UL-94
Good <sup>b</sup> dependent on proper curing	2,000hr exposure no change G-23	1,000hr exposure no change G-23	1,000hr exposure no change G-23 <sup>c</sup> FAILED TEST
n=0.013	n=0.011	n=0.008	n=0.010
Poor	Good	Good	Good

## Edge protection

The exposed edge of the trench helps hold the grate in position and is subject to the same loads as the grate. In addition to the effect of climate and weight of vehicles, it may be exposed to impact from items being dropped or pulled across it (e.g. snow plows). Once the edge fails, the grate will move and cause catastrophic failure.

Metal edges are most commonly used to withstand the abuse of traffic. Edge protection rails should be integrally cast-in or mechanically connected to the trench body. Edge rails that sit over existing standard edges are often ill-fitting and susceptible to failure.

Edge protection rails also provide some protection during installation, particularly if the wearing course of the pavement is not applied immediately. Appropriate edge protection is particularly important in asphalt situations where rolling machines can damage trench edges, leading to premature failure of the trench.

a. Equals 6.25 x √ compressive strength (psi) - (PCA Design & Control of Concrete Mixtures - 14th ed)  
 b. Carbonation can affect steel rebar leading to poor weathering (PCA Design & Control of Concrete Mixtures - 14th ed)  
 c. Bending exceeded 5% strain - unable to complete test

## 2.c Application - User Requirements

Once a trench drain is chosen to meet hydraulic performance, loading and durability requirements, the final options relate to project specific end user needs or legislative obligations:

### 1. *Aesthetics*



### 2. *Legislative requirements*



### 3. *User safety*



### 4. *Grate security*



The grate is the most visible part of the trench drain and aesthetically the most important.

Grates can be selected to 'blend' into the pavement, or used as a feature, or border.

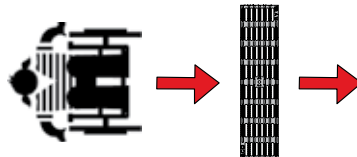
Once hydraulics, loading and chemical resistance requirements are met, the decision is based on visual or cost preferences.

- Grate materials - stainless steel, ductile iron, plastic and brass can all offer excellent aesthetics.
- Grate slot patterns - perforated, slotted, mesh and decorative patterns are available.



ADA requirements are set out in The Americans with Disabilities Act of 1990; Section 4.5.4.

*'Where grates are used within walking surfaces, the open slots should be no greater than 0.5 inches (12.7mm) wide in one direction. Where the length of the slot is greater than 0.5 inches, the opening should run perpendicular to the main direction of traffic.'*



The diagram shows the slots perpendicular to the flow of traffic; this helps prevent wheelchair wheels and walking aids becoming trapped or slipping on the grate surface.



ASME: A112.6.3 - 2001: Section 7.12 Heel Resistant Strainers and Grates.

*'A grate designed to resist entry of high-heeled shoes, in which the maximum grate hole size in least dimension shall be 5/16 in. (8mm).'*

ACO offers a range of 'Heelsafe' grates designed to prevent small stiletto style heels becoming trapped, causing injury or falls.



No US Standard exists detailing slot sizes to avoid bicycle tires becoming trapped.

Australian Standard AS 3996 - 2006 Clause 3.3.6 specifies maximum slot length dependent on slot width for grates that are deemed 'Bicycle Tire Penetration Resistant.'

ACO offers bicycle safe grates determined not to have slots large enough to trap modern bicycle wheels based on this Australian Standard.

ACO recommends that grates should be secured to prevent movement by traffic, which can cause damage to the trench and/or grate.

There are a number of locking options available, these include:

- Boltless locking - mechanisms that hold grates captive without use of bolts. They are quick to install and remove, making installation and maintenance easier.
- Bolt locking - uses bolts to hold grates in place. Bolts fasten into either the frame or locking bar that straddles the trench.
- Other lockings - on rare occasions, something other than standard lockings are required - please contact ACO.

