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CTIOA REPORT 2008-3-27

SUBJECT: SLOPE TO DRAIN

By: CTIOA Technical Committee
Slope to drain subcommittee

Floor and Area Drains

Introduction

Floor drains and accessories combine to form the upstream or entrance terminals of a building's floor drainage system. Area drains serve in a similar capacity for drainage of surface areas immediately adjacent to the building. The selection and specification of drains for interior floor areas and exterior surface areas merit careful consideration. Such factors as size, shape, function and anticipated drainage requirements of the area must be taken into account when planning for adequate and proper drainage of the area. These elements are of equal importance when sizing and locating the drains and drainage lines to which they are connected. Furthermore, many factors concerning plumbing and building codes apply, so it is recommended that they be consulted at the outset of selection and specification considerations.

Sizing

The potential volume of drainage to be accommodated by drains serving interior areas can, as a rule, be calculated with reasonable accuracy using the total amount of water within the area as a basis for sizing. The area's function as well as types of water use equipment used within the area must be considered. For example, a public restroom, with its numerous types of water use fixtures, must include drains sized and located to handle potential overflow due to stoppage as well as routine custodial waste from cleaning byproducts. In addition to plumbing fixtures, water requiring floor drainage emanates from man's sources such as run-off from vehicles in garage areas, condensate waste and processed water discharge from equipment hose stations, and emergency drainage as from sprinkler systems or spills. It is a good practice to provide floor drains in any area where a water source is located. Moreover, floor drains should be adequately sized and strategically located to avoid standing water on the floor, a potentially hazardous condition. Sizing of the area drains for surfaces adjacent to the building is normally based on rainfall and size of the area to be drained. Placement of area drains depends on the topography of the area with drains placed at the low points where run-off is anticipated.

Location Requirements

The locations within and adjacent to the building structure which require provisions for drainage are many. Some significant locations for which drains must be selected are toilet and shower rooms, boiler and equipment rooms, basements, garage and parking areas, kitchens, laundry, utility and service rooms, elevator pits, entry areas, machining and processing areas,

refrigeration rooms…the list goes on and on. Drains should be considered and selected for any location where water is supplied and surface drainage must be accommodated.

Different Codes requirements

Plumbing and Drainage Institute (PDI) - All areas which are subject to water spillage overflow of washing equipment or cleaning water shall have an approved floor drain installed.

Every public restroom shall have not less than one (1) approved floor drain connected to the sanitary system. One floor drain shall be installed for each 400 sq. ft. of floor area or major fraction thereof.

Uniform Plumbing Codes (UPC) – Floor drains shall be installed at the following areas:

- Toilet rooms containing two (2) or more water closets or a combination of one (1) water closet and one (1) urinal, except in dwelling unit.
- Commercial kitchens.
- Laundry rooms in commercial buildings and common laundry facilities in multi-family dwelling buildings

Compliance with ADA

In order to comply with the American Disabilities Act (ADA), drains located in walking surfaces or along accessible routes must have grate openings no greater than ½ in. (13mm) in one direction. If the grate openings are elongated, then the openings must be oriented so that long dimension is perpendicular to the dominant direction of travel.

Also, the maximum allowed slope of floor is 2% per foot in any direction which does not agree with other codes, requiring having a minimum of 2% slope.

Sizing Considerations

The size of the floor drains is important as it affects the number of drains required and the amount of water which can be efficiently drained. As a general reference, floor drains should be able to handle an overflow condition of water that may be discharged on the floor. The chart bellow indicated water outlets and the demand (GPM) requirements for a drain.

Type of Water Outlet	Demand (GPM)
Aspirator Operating room or Laboratory	2.5
Ball Cock in Water Closet Flush Tank	3.0
Bath Faucet, ½"	5.0
Dishwashing Machine	4.0
Drinking Fountain Jet	0.75
Hose Bibb or Sill Cock, ½"	5.0
Laundry Faucet, ½"	5.0
Laundry Machine (8 lbs.)	4.0
Ordinary Lavatory Faucet	2.0
Self-Closing Lavatory Faucet	2.5
Shower Head, ½"	5.0
Sink Faucet ⅜" or ½"	4.5
Sink Faucet ¾"	6.0
¾" Flush Valve (15 PSI Flow Pressure)	15
1" Flush Valve (15 PSI Flow Pressure)	27
1" Flush Valve (25 PSI Flow Pressure)	35

Free Area Calculation

A drain's top size, regardless of its shape: round, square, etc. – influences the number and size of openings between support members, which in total account for the grate's open or the free area. Normally, the larger the top, the greater the free area. Free area is the key factor used in evaluating the grate's ability to permit sufficient drainage to enter the drain for efficient utilization of the drainage system and prevent build-up of water of the floor or area served by the drain. Codes and standards stipulate that for proper drainage, interior floor drains should have a grate free area equal to one and one-half times the transverse area of the connecting pipe and exterior area drains, subject to rain-fall, two times that of the connecting pipe. Thus, it is important in selection of floor and area drains to consider the top and outlets sizes as they relate to each other.

Recommended Grate Free Areas for Various Outlet Pipe Sizes

Nominal Pipe Size IN	Transverse Area of Pipe SQ IN	Minimum Flow Requirements (Interior Areas) SQ IN	Minimum Flow Requirements (Exterior Areas) SQ IN
1½	2.04	3.06	4.08
2	3.14	4.71	6.28
3	7.06	10.59	14.12
4	12.60	18.90	25.20
5	19.60	29.40	39.20
6	28.30	42.45	56.60
8	50.25	75.38	100.50

Load Bearing

Once installed, floor drains become integral components of the floor or area in which they are located. Therefore, the drain selected for each installation must have tops or grates capable of sustaining the type of load to be supported by the floor. This is particularly significant where drains selected are installed in traffic locations. It is recognized that top-loading requirements vary with the location, type of construction and service conditions. These requirements for floor and are drains are addressed in American National Standards Institute, Floor Drains, ANSI A112.21.1M-1991 with the following five top loading classifications:

Light Duty – all grates having safe live load under 2000 lbs

Medium Duty – all grates having safe live load between 2000 and 4999 lbs.

Heavy Duty – all grates having safe live load between 5000 and 7499 lbs.

Extra Heavy Duty – all grates having safe live load between 7500 and 10,000 lbs.

Special Duty – all grates having safe live load over 10,000 lbs.

The safe live load is computed by dividing the load at failure by two when the grate is loaded in accordance with the test procedure stipulated in the Standard. A 3 ½" diameter platen was used during the load rating test and applied to the center of the grate. Using these top-loading classifications as a guide when loading requirements for the drains in a given location have been determined, the duty type required can be selected.

Sanitary Floor Drains/Sinks

Sanitary floor sinks are specified for indirect waste reception, generally in food preparation and clinical applications. Sanitary floor sinks are characterized by the acid resistant, smooth porcelain enamel coated, or stainless steel, interior surface and grate. Rounded corners on the inside and top rim of the sink eliminate areas where pockets of waste and bacteria might otherwise accumulate.

Floor sinks are usually furnished with sediment buckets and dome strainers.

Sediment buckets are used when debris such as peelings, vegetable cuttings, bones, pits and other solid waste kitchen material is to be intercepted and retained.

The regularly furnished dome type strainers are preferred because their hemispherical design greatly reduces splashing and their large free area prevents clogging, and assures maximum flow.

Floor sinks are not designed for traffic, and generally should not be specified in areas where foot or other traffic is anticipated.

Roof Drains

Flat roof drainage is accomplished through a system of roof drains, vertical leaders, and horizontal storm drains sized and located in accordance with established criteria in conformance with local plumbing and building codes. Therefore, when considering the design of a roof drainage system, it is recommended that local code authorities be consulted regarding the rainfall rate acceptable in their jurisdiction for design purposes.

There are three helpful things to know about getting water off the roof. First, water sitting on a roof can increase the amount of damage, as there is more water to get in the system when the roof leaks. Second, roofs require drainage so that the water is not there to accelerate deterioration of the roof membrane. Third, water removal helps reduce the dead load on the building. Water weighs 5 pounds per square foot for each inch of depth. If the weight causes a structural deflection, then additional water will flow into those areas and increase the load, which increases the deflection until structural collapse is the means by which the roof drains.

The ICBO Uniform Building Code and the BOCA Standard Building Code both require that all roofs have a minimum 1/4:12 slope to drain. In addition, good roofing practice suggests that drains be spaced no more than 75 feet apart. As roof maintenance includes cleaning drains, overflow scuppers are unlikely to be used, but should be employed at a height not more than 2 inches above the roof surface. Overflow scuppers should not be placed on the north wall in cold climates as they can ice up; ideally, they should be in highly visible locations. If water is coming out, then the primary drains are not working and it is urgent to get the primaries operating quickly. One suggestion is to place the scuppers over the main entrances, which make them hard to ignore.

Slope to drain

Slope is an inclined ground surface, the inclination of which is expressed as a ratio of horizontal distance to vertical distance.

Slope should be inclined enough to facilitate adequate water flow and prevent puddles, but not too much as to avoid slip and fall hazardous.

In our industry the slope to drain is usually required to be a minimum of ¼" per foot or a ratio of 1:48.

Careful attention should be given to the process of calculating qty of drains needed; as it will influence the slope design and the total thickness gained on the slop fill between the drain and the perimeter.

A uniform slop cannot be achieved unless the area needed to be slopped is a perfect circle and the drain is placed in dead center. In some cases, the Min. and Max slope required by the code is unachievable.

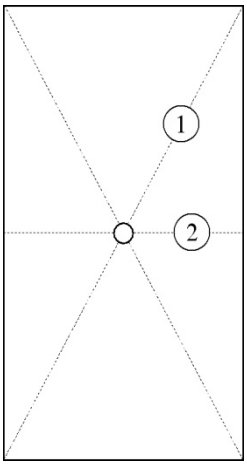

Figure 1:

This figure is an example of problematic design when it comes to uniform slope, or even maintaining the Min. and Maximum slope allowed in building codes. The slope rate on the longest line ① cannot be at the same slope rate as the shortest line ②

If fill is required to receive floor tile and mortar bed, or to provide necessary slope, it shall be specified to be a least 1-½ inches of uniform thickness. Consequently it is efficient to slope the substrate in order to avoid heavy and expensive slope fill and potential height differences with adjacent floors.

When specifying a slope for an exterior roof deck it should be calculated carefully to accommodate all components thickness, such as slope fill (if not built in subfloor) Waterproof membrane, drainage layer, wire reinforced mortar bed, and tile or stone.

For example: on a 15 feet long slope distance between the drain and the deck perimeter the total thickness at the perimeter could be as much as follow:

Description	*Thickness*
Slope fill	3.75"
Waterproof membrane	0.25"
Drainage layer	0.33"- 1"
Reinforced mortar bed	1.5"
Tile	0.33" – 2"
Bonding coat	0.25" – 0.75"
Total Thickness	6.41" – 9.25"

Few important notes:

- The Maximum permissible variation in the plane or slope ¼-inch in 10 feet (6 mm in 3 m) from the required plane when measured with a straight edge.
- It should be mentioned that all small horizontal surfaces in wet area such as shower curbs, seats, pony walls, niches and shampoo shelves tub rims and window sills are also part of the wet area; therefore, shall have a slope such that any fluid on their surfaces flows towards the drain.
- CBU's cannot be used on floors that are sloped to a drain

Slope, percentage, and ratio

Slope is commonly used to describe the measurement of the steepness, incline, gradient or grade of a straight line. A higher slope value indicates a steeper incline. The slope is defined as the ratio of the "rise" divided by the "run" between two points on a line, or in other words, the ratio of the altitude change to the horizontal distance between any two points on the line. It is also always the same thing as how many “rises” in one run.

Rise means how many units you move up or down from point to point. On the graph that would be a change in the “y” values.

Run means how far left or right you move from point to point. On the graph, that would mean a change of “x” values.

See Figure 2 on the next column for some visuals to help you with this definition:

Percentage

A percentage is a way of expressing a number as a fraction of 100 (per cent meaning "per hundred"). It is often denoted using the percent sign, "%". For example, 45% (read as "forty five percent") is equal to 45/100, or 0.45.

Percentages are used to express how large one quantity is relative to another quantity.

The first quantity usually represents a part of, or a change in, the second quantity. For example, an increase of $ 0.15 on a price of $ 2.50 is an increase by a fraction of 0.15/2.50 = 0.06. Expressed as a percentage, this is therefore a 6% increase.

Percentages are often used to express fractions of the total. For example, 25% means 25/100 or "one quarter".

Ratio

A ratio is a quantity that denotes the proportional amount or magnitude of one quantity relative to another. Fractions and percentages are both specific applications of ratios. Fractions relate the part (the numerator) to the whole (the denominator) while percentages indicate parts per hundred.

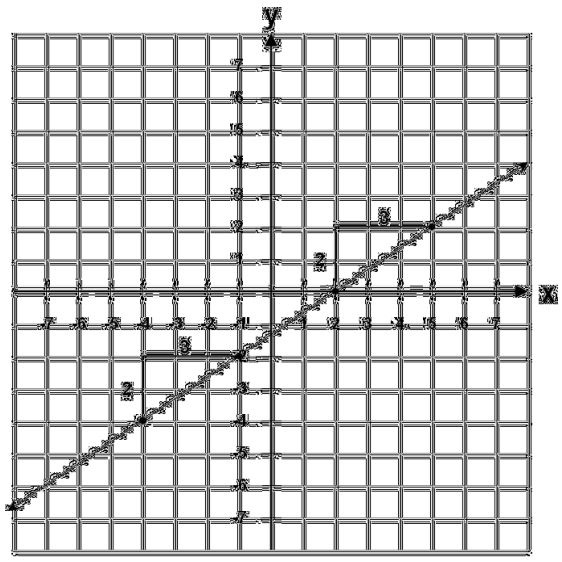

Figure 2.

Slope Description	Ratio	Remarks
⅛ inch per foot	1:96	**Similar inclination to 1% slope but not Identical**
¼ inch per foot	1:48	**Similar inclination to 2% slope but not Identical**
⅜ inch per foot	1:32	**Similar inclination to 3% slope but not Identical**
½ inch per foot	1:24	**Similar inclination to 4% slope but not Identical**
1% slope	1:100	**One rise can enter 100 times in one run**
2% slope	1:50	**One rise can enter 50 times in one run**
3% slope	1:33.3	**One rise can enter 33.3 times in one run**
4% slope	**1:25**	**One rise can enter 25 times in one run**

The simplest way is to measure the slope in percentage using the formula given in Fig. 3, below while:

L – Is the length of the slope.
H – Is the height difference.

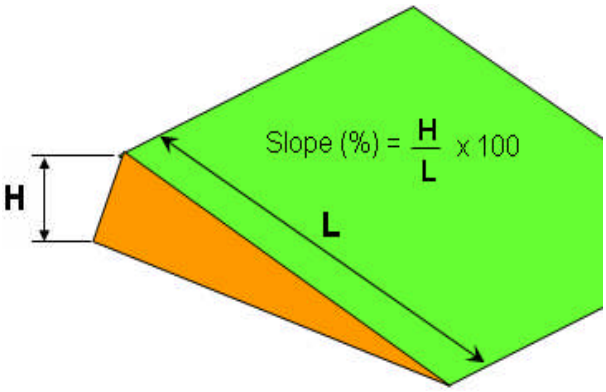

Figure 3.

Verbiage from Various Codes and Standards

ANSI A108.01.2.2 – Specify floor drains to comply with ANSI A112.21. Slope in subfloor shall be specified in sections such as concrete or carpentry and not with the mortar setting bed. Mortar bed to be of uniform thickness.

ANSI A108.3.6.2 – Prior to applying waterproof membranes, most plumbing codes require that floors of showers and roman tubs be sloped, by means of a smooth and solidly-formed sloping sub-base, to weep holes located in clamp style drains

Note - all horizontal ledges/rims shall have a slope such that any fluid on their surfaces flows towards the drain.

Uniform Plumbing Code Chapter 4

411.8 – (Edited) all lining materials shall be pitched one quarter (1/4) inch per foot (20.9 mm/m) to weep holes in the subdrain of a smooth and solidly formed subbase.

411.6 - (Edited) The finished floor of the receptor shall slope uniformly from the sides toward the drain not less than one-quarter (1/4) inch per foot (20.9 mm/m), nor more than one-half (1/2) inch per foot (41.8 mm/m).

411.4 Floor Slope. Floors shall be sloped to floor drains.

411.9 (Edited) Floors of public shower rooms shall… and shall be sloped not less than two (2) percent toward drains.

MIA DSDM Version VII

Horizontal Surfaces/Exterior Stone Paving

3.1 Mortar Bed Bonded to Concrete Subsurface

3.1.1 Preparatory Work. Adequate slope for surface drainage must be provided in rough concrete slab. Before being installed, all stone must be clean and free of foreign matter of any kind.

Wet Areas/Stone Shower Partitions

3.1.1 Waterproofing is the responsibility of other trades prior to installation of stone, and must be pre-sloped to the shower drain at a minimum pitch of ¼" per foot.

Wet Areas/Stone Slab Residential

3.1.1 Shower pan or waterproofing must be sloped to a minimum pitch of ¼"per foot to the weepholes of the shower drain.

4.0 Installation – Steam Rooms and Steam Showers

4.1 Preparatory Work - A waterproofing membrane must extend a minimum of 3" above the top of the finished surface of the curb. All backup surfaces must be waterproofed with a membrane authorized by the Manufacturer for steam room applications. All horizontal surfaces shall be sloped to a minimum pitch of ¼" per foot toward the shower drain assembly. Avoid liquefied waterproofing membranes.

4.4 Shower floors must be sloped toward the shower drain assembly at a minimum pitch of ¼" per linear foot and a maximum pitch of ½" per linear foot.

Wet Areas/Stone Tile Residential

3.2.1 Subfloor must be sloped toward the shower drain assembly at a minimum pitch of ¼" per linear foot. Finished floor must be sloped toward the shower drain assembly at a minimum pitch of ¼" per linear foot and a maximum pitch of ½" per linear foot.

5.3.5 (Edited) Slope finished surfaces of shower curbs at a minimum pitch of ¼" per foot so that water will run back into the shower. Ensure that shower floors are sloped toward the shower drain assembly at a minimum pitch of ¼" per linear foot and a maximum pitch of ½" per linear foot.

2001 California Building Code, Table 1109a.2-2

When a shower stall is provided in an accessible dwelling unit, at least one shower stall shall measure at least 42 inches wide by 48 inches (1067 mm by 1219 mm) deep with an entrance opening of at least 36 inches (914 mm). When a threshold (a recessed drop) is used, it shall be a maximum of ½ inch (12.7 mm) in height and have a beveled or sloped angle not exceeding 45 degrees from the horizontal. Maximum slope of the shower floor shall be 1/2 inch (12.7 mm) per foot in any direction and shall slope toward the rear to a drain located within 6 inches (152 mm) of the rear wall. The floor surfaces shall be of Carborundum or grit-faced tile or of material providing equivalent slip resistance.

References:

- *ZURN – Specification Drainage Engineering Guide. www.zurn.com*
- *WATTS DRAINAGE – www.watts.com*
- *JAY R. SMITH MFG. CO. – www.jrsmith.com*
- *THE PLUMBING AND DRAINAGE INSTITUTE – A Guide for Code Authorities and Others for Selected plumbing and Drainage products. www.pdionline.org*
- *"SANITARY FLOOR DRAINS" – by S. J. McDanal, CET, CIPE, CPD, Vice President Engineering. Jay R. Smith Mfg. Co.*
- *MIFAB - Manufacturer of Engineered Plumbing Products MIFAB – Floor Drain Selection Guide. www.mifab.com*
- *ADA 4.3.7*
- *CA T24 1115B.6.4*

Notes: