RAINWATER PONDING ON THE FLAT ROOFS

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INTRODUCTION

During The recent rainfall the roof of the bus shelter at Somanur had collapsed. The reason for the failure is PONDING which is one of the causes attributed by many engineers who visited the site. Even though the other causes may contribute the failure of the roof elements but the ponding forces cannot be neglected.

Collapse of roof structure may happen due to many reasons-for instances

1. By not providing sufficient number of drains.
2. By not specifying proper roof slope for the drainage of rain water.
3. By not properly maintaining the drains.
4. And the structural engineer may not account for ponding.

Please note that while designing the members the structural engineer refers to the code wherein the span depth ratio is furnished for preliminary design. The span depth ratio if used for design there is no need to check the deflection in many cases. But it should be kept in mind that this criteria does not take into account the ponding effect. Communication in the design stage between different design groups-architect,electrical engineer, mechanical engineer and interior designer etc is the key to a successful roof design. Poding effect on steel roof member is more severe as the roof covering sheet is a lighter than the reinforced concrete slab element.

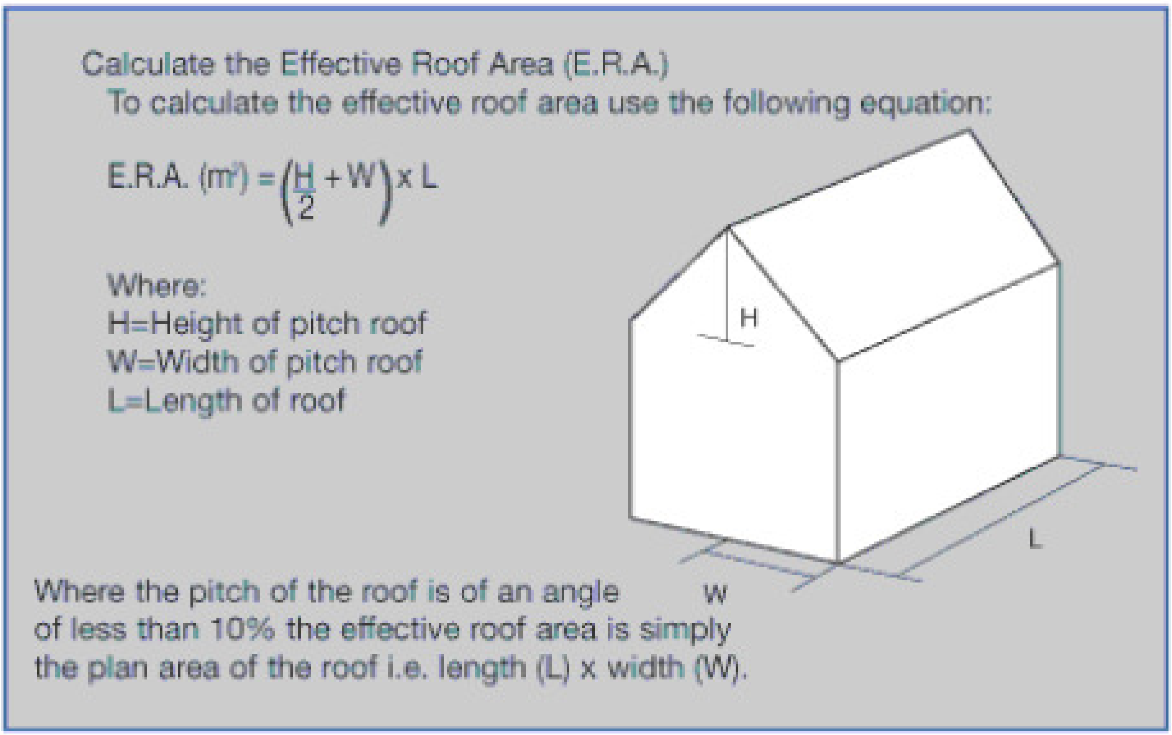
DESIGN ASPECT:

The code specifies a minimum LIVE LOAD of 1.5Kn/sq.m if roof access is available else 0.76Kn/sq.m. The load is reduced if roof slope is provided. The structural engineer on the above basis designs the roof slab and roof beams by not accounting for the ponding effect. Note that 1” of water depth creates a load of 0.25Kn/sq.m and as per the code if no LL on the roof while raining days it can accommodate an equivalent depth of 6” water depth and if the depth of collected water exceed the above load will cause a failure. As per the Manual for the roof drainage systems the allowable live loading on the roof will usually determine the maximum design water depth. Clause NE.2.10.3 of BS EN 12056-3 mentions that a maximum design water of 35mm at outlets has traditionally been acceptable for nominally flat roofs laid to falls.

Rainwater ponding can be prevented by adequate construction practice. A flat R.C.C. slab laid to slope of 1 in 40 is good enough to drain the entire rainwater. In heavy rainfall regions a steeper slope i.e 1:20 cab be provided. The minimum outlet pipe shall not be less than 75mm diameter. From practical point of view each 100 mm diameter pipes can serve an area of 40 to 50 sq,m.

The rainwater load is of minor importance compared with other live loads on the roof, like snow and wind loads, in case the roof structure has a sufficient slope, stiffness and number of emergency drains measures.

A simple methodology for roof drainage design is shown below but for further information regarding roof drainage refer to BS6367:1983 “Code of practice for the drainage of roofs and paved areas”.



The responsibility of structural engineer is to check whether the architect provides the minimum requirements such as

a. The maximum area per drain is equal to 929 sq.m (10,000sft) with a minimum of two drains per roof area.
b. The maximum spacing between drains should not exceed 24m(80ft).
c. Check the proper slope provided in the weathering course if it is a flat roof. Use of a 1/” per foot roof pitch which is 2% slope is preferable. If less slope is proposed then ponding effects on slab and beam elements should be investigated about its adequacy.
d. Check whether drains are placed at low points of the roof and whether there are still “bird’s bath” of water ponding after 24 hours or more after a rainfall. This may

indicate a ponding instability or even a local building column settlement condition which needs a careful investigation. The following table is a guide for the drainage pie and roof area.

e. Table 1-roof drain flow rate 100mm/hour(4"/hr)

Drain Size	Flow Rate	Equivalent Roof Area
50mm(2 inch)	114 Liter (30gpm)	------------
75mm(3 inch)	348 Liter(92gpm)	206 sq.m(2212sft)
100mm(4inch)	727 Liter(192gpm)	429 sq.m(4615sft)
125mm(5inch)	1363 Liter(360gpm)	804 sq.m(8653sft)
150mm(6inch)	2131 Liter(563gpm)	1257 sq.m(13,533sft)
200mm(8inch)	4573 Liter(1208gpm)	2698 Sq.m(29038sft)

Table 2:Horizontal Rainwater piping

Flow Rate based on rainfall intensity=100mm/hr

Pipe Size	1/8" Pipe Slope	1/4" Pipe Slope	1/2" Pipe Slope
75mm(3")	129 Liter(76 sq.m) 34gpm(822sft)	46gpm(1160sft) 174 Liter(108 sq.m)	69gpm(1644sft) 261 Liter(153 sq.m)
100mm(4")	295 Liter(175 sq.m) 78gpm(1880sft)	110gpm(2650sft) 416 Liter(246 sq.m)	157gpm(3760sft) 594 Liter(349 sq.m)
125mm(5")	526 Liter(310 sq.m) 139gpm(3340sft)	197gpm(4720sft) 746 Liter(439 sq.m)	278gpm(6680sft) 1052 Liter(621 sq.m)
150mm(6")	844 Liter(497 sq.m) 223gpm(5350sft)	315gpm(7550sft) 1192 Liter(701 sq.m)	446gpm(10700sft) 1688 Liter(994 sq.m)
200mm(8")	1813 Liter(1068 sq.m) 479gpm(11500sft)	679gpm(16,300sft) 2570 Liter(1514 sq.m)	958gpm(23000sft) 3626 Liter(2137 sq.m)
250mm(10")	3267 Liter(1923 sq.m) 863gpm(20,700sft)	1217gpm(29,200sft) 4607 Liter(2112 sq.m)	1725gpm(41,400sft) 6530 Liter(3846 sq.m)
300mm(12")	5254 Liter(3094 sq.m) 1388gpm(33,300sft)	1958gpm(47,000sft) 7412 Liter(4366 sq.m)	2775gpm(66,000sft) 10505 Liter(6132 sq.m)
375mm(15")	9384 Liter(5527 sq.m) 2479gpm(59,500sft)	3500gpm(84,000sft) 13249 Liter(7804 sq.m)	4958gpm(111,900sft) 18768 Liter(111900 sq.m)

*The equivalent projected roof area is shown in parenthesis for each drain size and horizontal storm drain placed at given slope.

The structural engineer in addition to DL and LL shall account for the rainwater load. He can refer to chapter 8 –Rainwater loading-ASCE-7-10 for rainwater load and its load combination.

A roof with adequate slope and good drainage will not only last longer but will require less costly repairs.

CONCLUSION:

It is important that the owner of the building should be informed the importance of periodic roof and portico slab and sunshades at optional six month periods the spring and fall and immediately after heavy rainfall and storm. Frequent maintenance can yield better result even if the roof system is poorly designed.

Ref:

1. ASCI-7-10 Minimum design loads for buildings and other structures.
2. Steel design guide series-guide 3 of AISC.
3. NRCA Roofing and Waterproofing Manual.
4. Manual for the design of Roof Drainage systes-A guide to the use of European Standard BS En 12056-3-2000 by RWP May.
5. British Standard 6367:1983.
6. Nabhi's Practical HB on Building Construction.

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