FLOOD

INTRODUCTION

Floods are the most frequent and costly natural disaster. According to the National Oceanic and Atmospheric Administration (NOAA) in the United States the 30 year average (1984 to 2013) annual loss due to flooding is $7.95 billion. For 2015 they stated there was a total of $2,12 billion in losses from flash flooding from both property and crop damage. There was $624.1 million in losses from riverine flood due to both property and crop damage. There was $15.9 million in losses from coastal flooding to property. In 2014 major flooding hit the Asia and Pacific region causing an estimated $16 billion in losses according to the United Nations Economic and Social Commission. In May 2014 Southeast Europe experienced over 1,55 billion Euro ($2.17 billion) losses in 10 countries.

Between 1998 and 2009, Europe suffered over 213 major damaging floods, including the catastrophic floods along the Danube and Elbe rivers in summer 2002. Severe floods in 2005 further reinforced the need for concerted action. In 2007 the European Union issued the EU Flood Directive to its member states which asked to all member states to assess the risk from flooding from rivers and from the sea. The member states have now developed detailed flood maps and have implemented coordinated measures across state borders to reduce the flood risk.

Flooding occurs in three means, from bodies of water such as lakes, rivers, and streams it is known as riverine or fluvial flooding, from the ocean known as coastal flooding and storm surge, and from rainfall known as surface water run-off, flash, and pluvial flooding. Riverine flooding occurs when the level of a body of water rises above the top of established channeling, such as a river bank or levees, and overflows onto land. A river is at flood stage when the overflow elevation is reached. Coastal flooding occurs when sea water overruns low lying coastal land not usually covered by tidal action. This can be attributed to a storm such as a hurricane, winter storm, typhoon, and nor'easter, Surface water run-off and flash flooding occurs when heavy rains or melting snow flow over the ground and accumulate in a low laying area. Sometime flash flooding occurs when the ground is either: frozen, too wet, or too dry for the water to be absorbed. It can also occur when the drainage system is overpowered by the amount of rainfall. Floods, from whatever cause, have one thing in common: they can cause widespread damage.

The Federal Emergency Management Agency (FEMA) has defined flooding as a general and temporary condition of partial or complete inundation of normally dry land from:

- The overflow of inland or tidal waters. (Riverine & coastal flooding respectively)
- The unusual and rapid accumulation or run-off of surface waters from any source. (Surface water run-off or flash flooding)

A flood prone area is a land area, usually adjoining a river, stream, watercourse, lake, bay or ocean, which is likely to be inundated under adverse conditions. Conditions sufficiently adverse to create flooding capable of damaging structures or buildings can originate from a variety of causes. However,

geographic location and elevation with respect to a threatening flood source are significant factors in determining the flood susceptibility of a property.

In the United States, riverine flooding is shown on Flood Insurance Rate Map (FIRM) published by FEMA. These maps show the 1% and 0.2% annual chance of occurrence (100 yr and 500 yr flood recurrence). Flood prone areas are referred to as:

- A Zones (area in the 1% annual chance of occurrence (100 yr recurrence))
- B Zones or shaded X Zones (area in the 1% to 0.2% annual chance of occurrence (100 to 500 yr recurrence)) Are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 1% annual chance of occurrence (100 yr recurrence), or shallow flooding areas with average depths of less than 1 ft (0.3 m) or drainage areas less than 1 mi^2 (2.6 km^2).
- C Zones or unshaded X, Zones (area above the 0.2% annual chance of occurrence (500 y recurrence))
- V Zones (coastal area in the 1% annual chance of occurrence (100 yr recurrence)).

The elevation of the 1% annual chance of occurrence is called the base flood elevation (BFE). This information will be on either the flood map or the Flood Hazard Study.

In England flood maps can be access through the Environmental Agency's website (https://www.gov.uk/check-flood-risk). The Environmental Agency rates the risk of flooding as "Very Low," "Low," "Medium," or "High." You can see the risk from both surface water and river or coastal water.

Flooding from surface water run-off is a temporary inundation of land when rain and snowmelt flows over the surface of the land. The water can accumulate in low-lying areas or in lower levels of buildings. Areas can be flooded due to frozen or hard soil, improper drainage, or inadequately maintained buildings. There are no maps published indicating what areas are subject to surface water.

Surface water run-off is normally not expected to enter a building; however, local topography may produce a watercourse channeling water into a building and causing damage. The hazard from this peril may be expected to be more severe in heavily paved areas and the urban environment because the pavement eliminates the opportunity for absorption of water into the natural subsurface ground water network. This loss of capacity for natural containment results in heavy surface flows.

One type of flooding that can be considered both riverine and surface water run-off is alluvial fan flooding. Alluvial fan flooding usually occurs in Texas, Arizona and New Mexico, where the land is relatively flat and the states are subject to quick, heavy rains. If the flooding occurs as a result of the water overflowing the defined river banks (either natural or man-made), this is considered riverine flooding. If the flooding occurs because the water flows through the property to get to the river, this is surface water run-off.

POSITION

Do not build structures in flood prone areas, areas susceptible to a 0.2% annual chance of occurrence (500-y). For those structures that are already located in the flood prone area, comply with the following:

- Develop a flood pre-emergency plan including flood mitigation and salvage
- Provide a FM Approved flood abatement equipment
- When allowed provide permanent flood protection barriers such as, levee, berms, channels or flood walls
- Move or raise all equipment to at least above the 0.2% annual chance of occurrence flood elevation

- Store important papers and spare parts above the 0.2% annual chance of occurrence flood elevation
- Provide manual shutoff valves on the sewer outlets and floor drains
- Analyze yard storage tanks, silos and large vessels to see if they can become buoyant during a flood

Include the following in flood pre-emergency plan: (See PRC.1.7.0.1 for additional details)

- Monitoring the level of the river
- For those areas where the flooding is caused by ice damming, monitoring the level of ice
- Inspection of all protection features such as, flood abatement equipment components, flood gates, levees, and berms
- Availability of sand and sandbagging material
- Working relationship with the fire department to coordinate a response if there is a fire
- Work plan for who is going to coordinate the relocation of equipment, papers and stock, who is going to survey the protection features during the flood and who has the authority to initiate the plan
- Equipment for cleanup operations including mops, brooms, chainsaws and other tools
- Call back plan to have employees return to help with the plan prior to the flood and to help cleanup after the flood

If flood protection barriers are planned, design and construct them in accordance with U.S. Army Corp of Engineers standards or to nationally recognized standards for facilities outside the United States.

Where flood protective barriers are installed, inspect the flood protection barriers annually by a trained person prior to the flood season and after each major flood. Take immediate corrective measures on any problem discovered during the inspection.

DISCUSSION

The most common cause of flooding is rainfall, whereby a combination of conditions interacts to maximize surface runoff. Monsoon rains of Vietnam and torrential rains of China, India and Bangladesh cause extensive flooding. Where infiltration of rain into the ground is not possible, such as in paved areas, water must flow overland. Direct rain on a watershed, melting snow, saturated ground, frozen ground or obstructed channeling may help cause the river water level to rise to flood stage. The amount of rain per unit time (intensity) and the total time of rainfall (duration) are important determinants of the magnitude of flooding. Localized, intense thunderstorms can create flood conditions in a small drainage basin. Larger cyclonic rainstorms of longer duration, but with less intense rainfall, generate more widespread precipitation over the watershed. When the rainfall becomes greater than the amount the ground can absorb, surface runoff moves the water overland. If rainfall is moderate and evenly distributed over the drainage basin, ground absorption may never be exceeded; therefore, the river level may not exceed flood stage. The same storm volume concentrated over a smaller area, however, may cause tributaries to rapidly reach flood stage.

Sites near rivers, streams or coastlines are generally susceptible to flooding, particularly if the ground elevation is very nearly the same as that of the threatening flood source. A site on relatively flat ground, regardless of its elevation above the nearest body of water, may just as easily become flooded by heavy rainfall surface runoff.

When streams, creeks or rivers overflow from heavy or prolonged rainfall, flooding may be limited or widespread, depending upon topography, watercourse characteristics and the extent of the flood plain. Unusually rapid snowmelt and ice jams, landslide damming, channel obstruction, or heavy precipitation may cause only local flooding in mountainous areas. In flat areas similar waterway conditions may create serious regional threats. Levees and dikes may fail, causing unexpected flooding in areas normally considered protected. For example, in spite of flood control projects

constructed along the Mississippi River, heavy rain and unusually rapid snowmelt periodically flood some areas of the river's drainage basin.

Widespread flooding also occurs with heavy rains of large tropical storms such as typhoons and hurricanes. The east coast of the United States and states adjacent to the Gulf of Mexico have been affected by hurricane related flooding along inland waterways as well as by coastal flooding from a single storm. Typhoons of Philippines, South Korea, Japan and the cyclones of Australia have created coastal flooding as well. Flooding from storm surge plus tide conditions may extend five miles or more inland, and water levels may range up to 15 ft (4.6 m) or more above normal along the coast. These abnormal conditions combine with the high rate of rain runoff to cause extraordinary water levels near the mouths of rivers and streams. At the same time, the wind driven waves (with or without rain) may cause damage to shoreline buildings, docks, seawalls and other structures. As the storm moves inland, high rates of rainfall saturate the region and runoff overwhelms the existing abnormal watercourses. Rivers and streams overflow, and flooding ensues.

FM Approvals have listings for flood abatement equipment for either opening barriers or temporary perimeter barriers. The opening barriers are listed for windows and doors, while the temporary perimeter barriers would be used around the buildings. The maximum height of water for the opening barriers is 5 ft (1.5 m). The maximum listing height for the temporary perimeter barriers is 3 ft (0.9 m). The test standard is ANSI/FM 2510 *Flood Abatement Equipment*. The height restriction is because the testing is conducted at the United States Army Corp of Engineers' (USACE) Engineering and Research Development Center (ERDC) Coastal and Hydraulics Laboratory in Vicksburg, Ms. The research facility consists of a 100 ft. (30.48 m) wide by 150 ft. (45.72 m) long wave basin with 4 ft. (1.22 m) high walls.

Flood depths deeper than 3 ft (0.9 m) can be protected using the listed temporary perimeter barriers according to the manufacturer's recommendations.

Flood Evaluation

High ground is less likely to be flooded than low ground. Prior flood history in a given area strongly indicates flood susceptibility. However, the lack of previous flooding should not cause complacency about future flooding. Flood data, including dates and flood levels, have been recorded in most inhabited areas. This data and other evidence of historical occurrences of flood levels have been analyzed to forecast statistically projected flood elevations. These statistical elevations are used to evaluate flood potential in the waterway flood plain. The flood potential for a drainage basin can also be statistically calculated.

The FIRM show flood hazard zones. The flood zone designation means that the periodic flood has been statistically calculated to occur on average once during that time and is projected to continue with that regularity. In current real time, there could be no floods or there could be more than one flood within the time frame.

Other countries around the world project other intervals of flood such as 0.5%, 0.1% annual chance of occurrence (200 yr, 1000 yrs recurrence), etc. Canada forecasts on 0.5% (200 yr) basis. North Sea studies looked at 0.25% and 0.05% annual chance of occurrence (400 and 2000 yr) events.

Floodproofing

Floodproofing includes design or modification of building or site features to reduce the potential for flood damage.

Permanent floodproofing may include providing levees, watertight walls and closures.

Permanent floodwalls and levees usually have been used for large areas; however, they also can be practical and economical for a small number of structures or a single structure. Floodwalls are generally constructed of masonry or concrete. Levees are usually earth embankments with low or moderately sloped sides. They must be constructed properly. The advantage of both levees and floodwalls is they can protect any type of structure.

Filling in a window, door or other opening with water-resistant material can provide a permanent closure. A sealant should be used to prevent seepage, especially in older concrete and brick walls. Contingent flood control measures require some type of installation or other preparation in anticipation of flooding. Flood shields, watertight doors or other protection devices must be placed and secured immediately prior to flooding. The major disadvantage of this type of protection is reliance upon the human element during a highly charged preflood time period.

If a new facility is proposed in a flood prone area, the builder could design the lowest floor to be above the base flood level. Fill, posts, piers or pilings may be used to elevate the structure. The builder should also ensure that structures are anchored to resist flotation and lateral movement associated with flooding.

Emergency Flood Protection

Emergency flood protection needs to be capable of placement on short notice. Activities must be carefully planned in advance. Plans should include material and apparatus storage, maintenance and personnel training. Emergency measures include building sandbag dikes and earthfill crib retaining walls. Sandbag dikes are constructed of earth or sand filled burlap or plastic bags that should be filled at the time of use. Crib retaining walls and stop log barriers are temporary walls of stacked timber planks that may be dropped into permanent side channels such as slots in concrete.

FLOOD GLOSSARY

Base Flood Elevation (BFE) - The elevation of the 1% chance of occurrence (100 yr flood recurrence).

Bank Full - The condition of a river in which the level of water has reached the top of the river bank and additional water will cause flow overland (flooding).

Coastal Flooding - Seawater elevation rise and over running of low lying coastal land not usually covered by tidal action. Such flooding often results from storm seiche and is accompanied by eroding wave action.

Drainage Basin - See Watershed

Flood - An overflow on lands not normally covered by water. Floods have two essential characteristics: the inundation of land is temporary; and the land is adjacent to and is inundated by overflow from a river, stream, lake, ocean or other body of water.

Flood Plain - Relatively flat area or low lands adjoining the channel of a river, stream, watercourse, ocean, lake or other body of water, which has been or may be covered by flood water.

Flood Stage - The stage or elevation at which overflow of the natural bounds of a river, stream, ocean, lake or other body of water begins.

Floodproofing - Any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to structures and their content.

Flood Wall - A man-made structure designed and constructed in accordance with sound engineering practices to contain, control or divert the flow of water to provide protection from flooding.

Levee - A man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control or divert the flow of water to provide protection from flooding.

Mean Sea Level - The average height of the sea for all stages of the tide. (Not the same as NGVD)

National Geodetic Vertical Datum (NGVD) - The datum reference elevation permanently established (with bench marks) water surface elevations to which tidal data are referred. This is the datum established by the U.S. Coast and Geodetic Survey in 1929.

PMF - (Probable Maximum Flood) - A calculated flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonable for the region.

River - “Water” VS “Pool” Elevation - These two items are closely associated. The “Pool Level” corresponds to the normal elevation of the water surface encountered at a placid section of the river as opposed to more turbulent water caused by a rapid change in elevation. “Low water” elevation when used in conjunction with flood analysis references the pool level. In some cases, low water may actually be the elevation of the river bottom.

River Profile - Elevations at various points along the river water surface at any particular flow condition. For flood analysis, the most valuable river profile would be the one at 1% chance of occurrence (100 yr flood recurrence) flood elevations.

Riverine Flood - Increased water elevation accompanied by overbank flow developed along the river profile.

Standard Project Flood - Such floods, as used by the US Army Corps of Engineers, are intended as practical expressions of the degree of protection that should be sought in the design of flood control projects. A recurrence frequency is not assigned to this flood.

Surface Water Run Off - (Ground surface water) - Run off from heavy rain or snowmelt is normally not expected to enter a building, however, local topography may produce a watercourse channeling water into a building and causing damage. Hazard potential due to this peril may be expected to be more severe in heavily paved areas and the urban environment because the pavement eliminates the opportunity for absorption of water into the natural subsurface ground water network. This loss of capacity for natural containment forces heavy surface flows.

Watershed/Drainage Basin - Every river consists of a major trunk segment fed by a number of branches that diminish in size away from and to higher elevation than the main stream. The many tributaries define a network of channels that drain a recognizably bounded area separated from the adjoining area by a divide, ridge or elevation rise. All precipitation within the ridge bound basin drains to the main river channel. Thus, all drainage within the basin from the watershed is fed to the main stream. The magnitude and duration of flooding is controlled by the size of the basin and the climatic conditions prevailing.

Statistical Analysis of stream flow records and calculation for postulated floods and flood-frequency estimates involves various correlations of flood characteristics, meteorologic hydrologic features of the drainage basin.