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BASIS OF FLOOD DAMAGE AND ITS ASSESMENT IN KASHMIR VALLEY

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Abstract

The damages caused by the flood water to the residential buildings are qualitatively defined by the numerical values in order to assess the damage. The numerical damage intensity scale is used to get the idea of potential destructiveness of flood waters. The numerical damage intensity scales or damage indices are calculated by considering both the structural damages and nonstructural damages in the buildings caused due to the flood water. The damage indices or numerical intensity scales derived are very effective in differentiating the damages in different buildings and hence gives the feasibility of retrofit or repair in the structures. This paper mainly covers the tangible damage caused by the flood waters.

Keywords: floodwater; Damage indices; numerical damage intensity scales; structural damage;nonstructuraldamage; tangible damage.

1. Introduction

In September,2014 the Jammu and Kashmir region suffered disastrous floods across many of its districts caused by torrential rainfall. The incessant rains that have occurred resulted in the excess discharge in the river Jhelum. The river Jhelum was flowing at a much higher discharge than its capacity. Due to this, the riveroverflows its banks and entered into the residential as well as in nonresidential areas. The water that has entered into the residential areas caused widespread damage to life and property.The damage caused by the flood water included washing away of the houses due to impact of the water under high stream velocity, damage caused by inundation of houses, scouring of the foundation of the house or the earth under the foundation and the damage caused by the debris carried by flood water.

This paper reviews to methodology that can be used to quantify the direct damage to the residential buildings caused by the flood waters. The major focus is on the damages caused to residential buildings and includes both structural as well as nonstructural damage.The tangible damage is quantified and thus the relationships between the flood characteristics and tangible damage to residential buildings is determined. The data of damage caused on residential buildings due to the floods are collected by means of surveys and inspections in the field.

The devastating effect of flood water on residential buildings can be attributed to the hydrodynamic, hydrostatic and impact loads of flood water.These load cases can often be exacerbated by the effects of water scouring soil from around and below the foundation. The hydrostatic loads are both lateral and vertical in nature. The lateral forces arise due to the difference in interior and exterior water surface elevations. The hydrodynamic loads cause frontal impact loads and drag forces on the sides of the building and the suction on the rear face of the building.

The damage in residential buildings due to the flood water is categorized in foundation or substructure damage and superstructure damage. The damage in the foundation include the settlement (preferably differential settlements). The superstructure damage includes the damages in the structural and nonstructural elements involving cracking,spalling, loss in moment or load carrying capacity, shear failures etc.

2. Damage Analysis

In order to get the complete knowledge of damage caused by the flood waters on residential buildings the process of damage analysis needs to be done. The damage analysis involves the collection of the damage data from the field and then subjecting the collected data to rigorous analysis both visual and mathematical to get the complete information or knowledge about the damage present in the structure. The objective of this paper is to formulate the general damage scales in order to quantify the damages in the structure so that more rational differentiation of damages can be done. From the structural standpoint the damage analysis will help in finding the functionality of various structural and nonstructural elements. For example, the functionality of foundation after flood water will mean if the foundation is still able to perform its intended purpose or if the life expectancy of the structure will have some effect due to the flood water. Thus damage analysis will give clear picture of the percentage loss in strength of different elements against the appropriate performance. The damage analysis will also help in determining the methods and scope for repair and restoration of the structure for restoring the structure to its original (pre flood) condition. The damage analysis will provide us the information about the construction or design deficiencies that lead to the damages in the buildings due to the flood waters.

3. Damage Intensity Scales(DAMAGE INDICES)

The damage data collected from the field is analyzed in order to define the present state of building in terms of its structural performance. The data is analyzed in such a way so as to incorporate all the factors in it which directly controls the structural performance of the structure. Damage index is a mathematical model for qualitative description of the damage and it has correlation with the actual damage. There are various ways to categories the damage indices. The simplest way is the correlation between the damage indices and the observed damage and also the correlation of stage of flood water with the damage indices

4. Formulation of the Damage Indices

The damage indices of the building are formulated taking various parameters of the damaged building into consideration. The different factors are given

4.1. Type of damage:

The type of damage or grade of damage is referred to IS 13935:2000 for masonry buildings. The grade of damage is given the overall weight age factor of 1, the maximum value because the grade of damage has maximum contribution to the damage index of the building. Table 1 shows the different grades of damage and their respective weight ages.

Table 1: Damage weight age factor assigned to different grades of damages in buildings (as per IS 13935:2000)

Grade of Damage (as per IS 13935:2000)	Weightage factor
G1	0.4
G2	0.6
G3	0.7
G4	0.9
G5	1

4.2. Floor**:**

The floor level of the building directly affects its damage level. The damage present in the ground floor has got more attention than the damage in the second floor or the first floor, since the damage present in the ground floor is reflected in the upper floors. This is opposite to the earthquake analysis where the upper floors are given more importance due to the progressive collapse mechanism of failure. Based on the above discussion the floor is given the overall weightage factor of 0.7. Table 2 shows the respective weightages to overall damage for different floor levels.

Table 2: Damage weightage factor to different floor levels in buildings

Floor level	**Weightage factor**
Ground floor	1
First Floor	0.9
Second floor	0.8

4.3. Material or type of the building:

The material and type of building also has very important contribution in calculating the damage index of the building .The materials like concrete ,steel resist the effects of flood waters very efficiently as compared to mud and unburnt bricks .The material of the building is given an overall weightage factor of 0.9 .Since the high grade material will try to resist the damage upto full capacity ,the low quality material is easily affected by flood waters .Table 03 shows the respective weightage factors for different types of materials in a building

Table 3: Damage weightage factors for different types of material in a building.

Type of material	**Weightage Factor**
Concrete	0.7
Bricks with mud mortar	1
Bricks with cement mortar	0.8

4.4. Location of the Damage:

The evaluation of the damage index of the structure also depends on the location of the damage. Since the location of the damage helps to find out its influence on other elements of the structure.e.g. the crack in the beam column junction is more serious than the crack at the center of the wall. The overall weightage factor for location of damage is 0.9. Table 4 shows the respective damage weightage factors for the location of the damage in the building.

Table 4: Damage weightage factors for location of the damage in the building

Location of the damage or crack	Weightage factor
Beams and columns (Framed Structures)	1
Walls (partition walls)	0.5
Walls (load bearing structures)	0.9
Plinth ,lintel and slab	0.8

4.5. Age of the building:

The age of the building also affects the damage indices of the building since the freshly placed construction materials work exceptionally well during the initial years and after long time material starts degrading due to loss in the stiffness of the structures. The overall weightage factor to the age of the building is 0.7.Table 5 shows the respective damage weightage factors for the age of the building.

Table 5:Damage weightage factors for the age of the building

Age of the building	Weightage Factor
≤ 20 years	0.6
20-40 years	0.7
40-60 years	0.8
60-80 years	0.9
80-100 years	1

5. Calculation of Damage Indices:

The final damage index of the building is calculated taking all the above attributes of the damage into consideration. The damage index will represent the damage qualitatively and is often descriptive. The damage index of the building will be formulated in table 6.

The two story masonry building made up of bricks with cement mortar whose age is 23 years has suffered the damage due to the flood water as follows:

Crack 1 of type G3 is present in the wall of ground floor. Another crack 2 of type G4 is present in the beam. There is a crack 3 of type G3 present at the lintel level of the building.

In the first floor crack 4of type G3 is present at the lintel level. Another crack 5of type G4 is present at the corner of the wall. The center of the wall has diagonal crack 6 of type G1.

For the above building the damage index is calculated as:

Table 6: Calculation of damage index of a building

DAMAGE	TYPE OF DAMAGE	FLOOR LEVEL	MATERIAL OF THE BUILDING	LOCATION OF THE DAMAGE	AGE OF THE BUILDING	Damage Index
Overall weightage Factor	**(1)**	**(0.7)**	**(0.9)**	**(0.9)**	**(0.7)**	
CRACK 1	0.7	1	0.8	0.9	1	(1×0.7) × (0.7×1) ×(0.9×0.8) × (0.9×0.9) × (0.7×1) **=0.200**
CRACK 2	0.9	1	0.8	1	1	(1×0.9) × (0.7×1) ×(0.9×0.8) × (0.9×1) × (0.7×1)**= 0.285**
CRACK 3	0.7	1	0.8	0.8	1	(1×0.7)×(0.7×1)×(0.9×0.8) × (0.9×0.8) ×(0.7×1)**=0.177**
CRACK 4	0.7	0.9	0.8	0.8	1	(1×0.7) ×(0.7×0.9)×(0.9×0.8) ×(0.9×0.8)× (0.7×1) **=0.160**
CRACK 5	0.9	0.9	0.8	0.9	1	(1×0.9) × (0.7×0.9) ×(0.9×0.8) × (0.9×0.9) ×(0.7×1) **=0.231**
CRACK 6	0.4	0.9	0.8	0.9	1	(1×0.4) × (0.7×0.9) ×(0.9×0.8) × (0.9×0.9) ×(0.7×1) **=0.102**
TOTAL DAMAGE INDEX OF THE BUILDING						0.200+0.285+0.177+0.160+0.231+0.102 =**1.155**

The damage index of the another damaged building is calculated in a similar way and thus after relating the damage indices of two buildings, the comparative level or severity of damage is understood.

6. Conclusion

The damage index of the building will help in relating the qualitative damage levels in the structure .The severity of the damage is related to the feasibility of repair and restoration of the structure .The maximum damage index that any damaged building can have as per above guidelines is 4.2.This means if any damaged building has damage index close to 4.2 ,then there is very less scope of repair and restoration in the structure .On the other hand if the damage index comes to be in the range of 1-3 , then the chances of repair and restoration are very good as they signify moderate damage.. The damage indices formulated can adequately predict the undamaged and collapse damage states of the building.

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