DESIGN OF MULTI-HAZARD RESISTANT AND SMART CIVIL ENGINEERING STRUCTURES FOR NEXT GENERATION

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ABSTRACT: Now a days, society and engineers have an challenge for energy management solutions, which can be achieved by increasing the insulation of buildings with green materials, using renewable energy sources, increasing the connection between the energy devices in this building, it also has better equipped energy productions and increasing the huge internal and external devices. Since the civil engineering designs has catastrophic consequences, all structure methods focus on structural safety like performance and resilience which are considered through structural health monitoring (SHM) methods. With economic, population growths, urbanization, climate indications and resources reduction, the building of structures must also consider the durability, sustainability and intelligent life cycle management, as well as safety, performance and resilience to meet society's need for sustainable development. This article explains the design of sustainable, multi-hazard, resilient and advanced structures. The five main parameters for next-generation structural development have been identified, including durability, longevity, multi-hazard resilience, advanced life cycle observation and management of structural condition. Complex evaluations and determination of every parameter is provided.

KEYWORDS: Smart Building, Energetic Efficiency, Home Automation, Sensors, Networks

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I. INTRODUCTION

In French technical universities, classic engineering courses are explained according to theoretical study: civil, electronic engineering, thermal, materials science. Recent problems, like shortage of energy, create skill is undefined by these conventional regulations.

However, a general engineer is choice that involves in these new jobs which are quite specialized. This is idea is to providemultidisciplinary training courses, which are suitable for new professions.

Natural hazards like earthquake and force poses wind that challenges to security and comforts. The force created by nature can do damages or destroy fragile structures. Risks to life and property from natural disasters are increasing due to urbanization as big cities and metropolitan cities becomes highly polluted. Land scarcity as well as urbanization requires constructing huge and more compound designs that may be further unprotected for forces caused by nature. Therefore, the impact of natural disasters on engineering designs is a significant area of research.

From 1998 the natural disasters affected worldwide 4.4 billions of population [3] and caused $2.9 trillion in economic losses. During this period, earthquakes (7.8%), storms(28.2%), and floods (43.4%) are affected commonly. While floods are common hazard at this period, remaining are the most dangerous and costly. Floods and earthquakes kills nearly millions of mankind and caused nearly $2 trillion in economic losses at this time. Death and financial losses happened by various kinds of disasters by nature.

Natural phenomena like wind and earthquakes dynamically affect constructing and remaining civil engineering designs. The damage caused by nature is based on characteristics of design, force by the wind as well as explosions. The damages are caused by excessive vibration and therefore, vibration regulates to reduce the vibration of designs subjected to static load which can be utilized as safety techniques [14]. It uses secondary active and passive or hybrid sensors mounted on the structures and designed/tuned/operated to optimally reduce structural responses like displacement, acceleration, etc. For example, foundation isolation is familiar and potent earthquake protection [16]. Tuned Mass Dampers (TMDs) and remaining additional sensors various structures with configuration that functionally reducing wind and earthquake induced shaking in various kinds of designs.

Vibration control methods will produce different preservation to existing designs if modification or build is deemed too expensive or impossible because parameters like elegance, culture considerations, etc. These controlling sensors which are essential towards the force produced by a kind of nature hazard which didn't affect the remaining [12]. As basic isolation model that effects the seismic protections for designs may react negatively in strong winds. Because uncertainty of the amplitudes and frequencies of the forces caused by nature and their relations with features of impacted designs, it is particularly significant to consider the multi-hazard scenario [5].

The searching result of natural hazards includes the articles that addressed the multi-threat problem based on one or more standards: (a) hazards mapping/quantifications, (b) Observations evaluation, (c) designs / optimizations, (c) vulnerability evaluation, (d) life-cycle / price-advantage evaluation, (e) vibrations control.

In addition, in 2018 the reports for United Nations Intergovernmental Panel on Climate Change (IPCC) explains about 2030 year, 45% of carbon dioxide will be reduced, and by 2050 reach zero. And the global warming upto 1.5 ◦C. Global Infrastructure Construction Market 2021 was estimated at 2.242 billion United States dollar, and in 2027 it should reach 3.267 billion. The Australian Government is evaluating. As120 billions in transport infrastructure is made over 10 years for constructing the powerful and highly resilient. Building and maintaining infrastructure consumes energy as well as causes pollutions. It is calculated that around 70% of global greenhouse gas emissions come from the constructions and operations of infrastructure.

The infrastructures under normal operating conditions inevitably deteriorates throughout its lifetime due to tiredness and corrosions; may be exposed to nature or man-made hazards like earthquakes, explosions, shocks, floods and fires, which may result in massive economic losses, casualties and social disruption. Maintaining dilapidated buildings and rebuilding harmed designs consumes huge natural resources, energy and contributes to greenhouse gas emissions. The safety and resilience of infrastructure that can withstand multiple hazards and adapts climate change which is critical to the economy and human security. Hence, the structures and constructions for coming generation of civil structures will consider sustainability, durability, resistance to various risks, resilience, intelligent observing and control – i.e. SDuMuRS designs.

II. LITERATURE SURVEY

Ettouney, M.M.; Alampalli, S, et.al [6] discusses hazard categorization of time, frequency and Newtonian features. It characterizations determines the co-occurrences, segregations over period, and cascades impacts. Frequency classification determinates the methods like corrosion from intermittent methods like earthquakes continuously. Irregular methods can be categorized as frequent, intermediate or infrequent. The Newtonian characteristic is a needed threat categorization method commonly utilized in structure codes. The hazards are usually specified as loads like natural hazards etc. The effects of the loads will be quantified in terms of various parameters like stress, strain, etc. and calculated based on Newtonian mechanics like dangers called Newtonian.

Duthinh, D.; Simiu, E, et.al [15] explains the standard practice of dealing with multiple hazards on own constructing structural elements for the most dangers. Using the natural hazards, they produced the provisions of Associated Criteria for Buildings and Other Structures are inconsistent in terms of risk, meaning that regions damaged by high winds as well as earthquakes it will have more the risk for limit state violations than regions if few of these hazards are predominates.

Kappes, M.S.; Keiler, M.; von Elverfeldt, K et al. [13] discusses the problems of multi-hazard risk analysis and available methods to explain applications.

Zaghi, A.E.; Padgett, J.E.; Bruneau, M.; Barbato, M.; Li, Y.; Mitrani-Reiser, J.; McBride, A et al. [9] explains the conditions of present structural regulations in moderately explain multi-hazard cases and require a general nomenclature for multi-hazard designs are described. It also point out many issues and demands associated with the design of multi-hazard.

H.R.Pourghasemi, A.Gayen, M.Edalat, M.Zarafshar, J.P.Tiefenbacher, et al. [1] explained the current road hazard of southern Iran map of Fars provinces. It is about landslide, volley and floods. They tested the different kinds of methods to predict the classification of these disasters based on historical data and using various aspects like elevations, drainages, average annual rainfalls, etc. They describe the significance of identifying more hazards for spatial planning, sustainable implementation and watershed development in particular region.

U.Barua, M.S.Akhter, M.A.Ansary, et al. [10] Provides a road hazards maps for various cities in Bangladesh based on local historical hazards databases as well as determination of risk with remaining countries. This analysis considers nature hazards that included using a weighting scheme.

B.K.Bhartia, E.H.Vanmarcke, et.al [18] described risk assessment methodology for marine designs that exposed to wind; waves and earth quakes. They take into account the probability of failure under short-term load and the complete risk arising from charge of various frequencies. The output describes the limited (failure) states, designs and characteristics of various kinds of loads interaction in a complex manner to control the significance of various risks. The aggravating effect in a multi-hazards situation is shown as example in the analysis of environmental stress (there is always sea wind) and seismic stress. A scheme was prepared for the detection of various risks and further evaluation.

Spencer, B.F.; Nagarajaiah, S, et.al [17] describes advances in semi-active structure vibrations controlling designs. It worked on smart damping sensors like MagnetoRheological (MR) devices combines the desired characteristics of passive, active steering solutions, good steering towards wind and earthquake forces.

Huang, M., et.al [7] explains an overview of dynamic solutions of tall structures exposed to various multi-hazards. Introducing performance evaluation designs and studies by utilizing huge structures in Hong Kong. Different parameters were considered in the analysis, including the distance from the epicenter to the site, repetition period, ground motion amplitude, building height, damping ratio, and wind force characteristics. The results show that compared to wind force, seismic loading results in higher ground accelerations responded for higher lateral force, while low torsion force and displacement responses. As wind response is highly sensitive as height changes than seismic is detected by the building height. The output shows the responses of wind which is highly affected by degree of building dampers than by seismic responses.

Aly, A.M.; Abburu, S, et.al [11] Shows the response of a skyscraper for seismic force as well as wind. The evaluations included the different skyscrapers (76 & 54stories respectively) for finite component determination. They detected that earth quakes excites high vibrations within the building that results a less drift between wind forces and floors, as huge ground frequencies with short duration. Wind effects will have great importance with respect to building comforts and serviceability. High-rise designs for high winds may be adequately tolerant of moderate ground shaking, but high ground acceleration can cause non-structural losses.

I.Venanzi, O.Lavan, L.Ierimonti, S.Fabrizi, et al. [4] described a framework for estimating life cycle losses due to nonstructural damage in huge buildings subjected to seismic loads and wind was presented. The analysis predicts the damage retained their original state after dangerous events. Minor maintenance costs are negligible because dangerous events do not occur at the same time. Their results show that wind power is more costly than seismic power as drift-dependent damage. Due to the high ground acceleration, seismic force is more damaging as non-structural damages.

X.W.Zheng, H.N. Li,; Y.B. Yang, G. Li, L.S. Huo, Y.Liu, et al. [2] described a method for damage risk assessments for tall buildings that are isolated and simultaneously exposed to wind and seismic forces. They used approximately 47 years of noted seismic and wind. The data will calculate wind, seismic hazard curves and copula-based bihazard surfaces. Then the performed multiple hazard vulnerability assessments and estimates damage probability for individual simultaneous hazards. The outputs describes the damaged probabilities because of the bihazard controlled the overall harms in highly damaged places. They emphasize the need to consider multiple hazards when designing and evaluating designs which exposed highly for wind and seismic force. Cost-benefit analysis of damage risk assessment and damage mitigation strategies in homes exposed to hurricane and earthquake forces.

A.M. Avossa, C.Demartino, P.Contestabile, F.Ricciardelli, D.Vicinanza, et al. [8] explained a Monte Carlo simulated-based design for estimating multi-hazards vulnerability curve for wind turbines. They demonstrate the application of the framework for deriving the probability of failure of a prototype wind turbine as a function of wind speed and maximum ground accelerations in various operating places of the wind turbines. The outputs indicate that an aerodynamic force performs a significant part in seismic vulnerability. Vulnerability for longitudinal seismic service conditions enhances with wind speed up for increased speed of wind. Then it starts decreasing.

III. METHODOLOGY

The initial phase will detect the source of the hazard. It is a hazard/multiple-hazard which requires to be determined based on the probabilistic consideration, and their relationships among the various kinds of nature destroys as they affect the structural response analysis. For example, as described above, when considering the

mainshock and aftershocks, it is necessary to consider the final damage state of the structure due to the mainshock as the initial state in subsequent aftershock analysis. Therefore, the numeric design for aftershocks determination must have variation from the numerical model for mainshock analysis.
The next step for project is designing the load for multiple-hazard. The next phase will develops a preliminary structure for needed functions for design and implements a comparing numeric model for structure analysis under multiple coincidence and/or sequential critical paths. As explained above, multiple risks have various parameters and uncertainties, so the analysis must be evaluated in a probabilistic design. Fragile curves and fragile plane are commonly used for analysis.

The performance of multiple compromised structures is then evaluated based on standards and stakeholder requirements. If the requirements are met, the designed structure is considered acceptable (or optimal). If not, the structure will need to be modified from the original design, and possibly retrofitting methods (such as attaching buckling-stressed stanchions to the bridge structure) can be used. This method should be repeated until an structure is obtained. Note that different hazard classifications result in different formation of corresponding vulnerability curves/regions.

The analysis and design framework is primarily based on highly used performed-structure methodologies. Today, modern design methodologies are evolving towards designs based on resilience. However, relevant research on resilience-based design considering multiple hazards are very limited. A framework is proposed to assess the resilience of complex designs in multiple hazards environments, It focus on transportation assets. This method consists of four steps. The first two steps of assessing resilience to multiple disasters are the same.

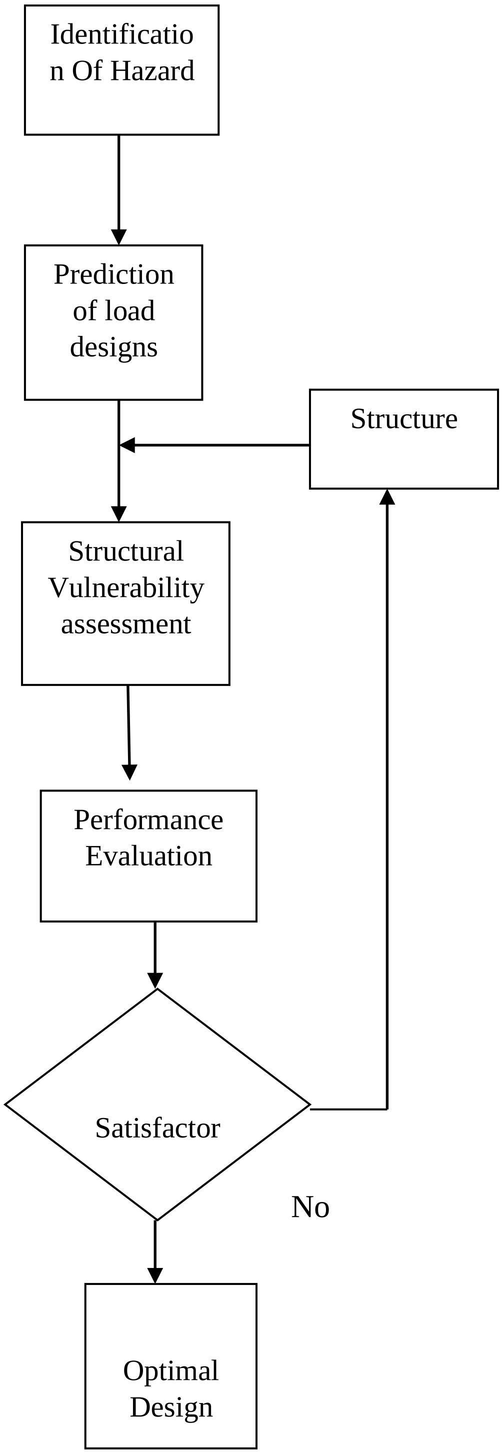

Fig.1: Flowchart Design Of Multi-Hazard Resistant And Smart Civil Engineering Structures For Next Generation

However, structural recovery and post-disaster recovery are considered key factors that have a significant impact on structural resilience, so recovery is considered more in the several hazards resilience assessment designs. Note that remediation strategies are affected by multiple hazard types. Different remediation strategies were based on multiple hazards are described in the analysis. As assessment of resilience's are typically presented in index. The resilience index is typically a time-varying function of the structures for features over recovery time of a particular hazard scenario.

The period of civil engineering structures, they may be exposed to various hazards. Analyzing structures exposed to multiple hazards is much more complex than analyzing a single hazard, because different hazards have different characteristics and relationships between different hazards are different. Extensive research has recently been conducted to assess performance of engineered structures exposed to multiple hazards. These are typically based on performance-based methods in a probabilistic design with vulnerability curves and vulnerability surfaces as metrics. Recently, some studies have also been performed to assess the resilience of structures when exposed to a hazard. The research assessing resilience to multiple hazards is very limited. More comprehensive research is needed the better understanding for performance of designs that exposed to multiple hazards, and improved resilience-based assessment is also needed.

IV. RESULT ANALYSIS

The performance analysis of Design of multi-Hazard resistant and smart civil engineering structures for next generation is discussed in this section. The comparision is seen interms of sustainability, durability, multi-hazard resistance and cost saving.

Table.1: Performance Analysis

Parameters	Multi-Hazard resistant	Monte Carlo simulation
Sustainability	99	95.2
Durability	95	89
Resistance	99.2	86.5
Cost	6757	8965

In Fig.2 sustainability comparision graph is observed between Multi-harzard and Monte Carlo.

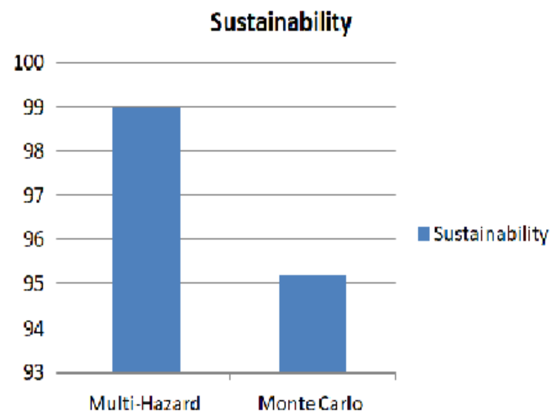

Fig.2 Sustainability Comparision Graph

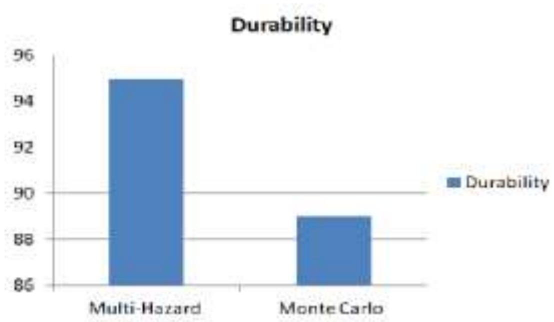

Fig.3 Durability Comparision Graph

In Fig.3 multi- harzard and Monte Carlo is compared for durability.

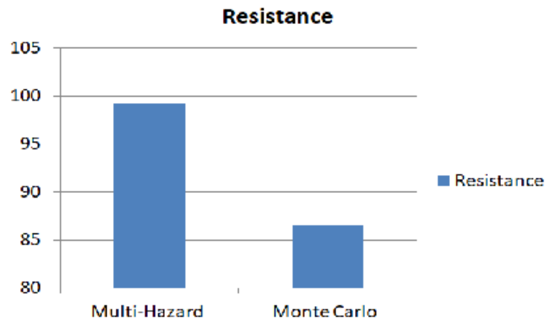

Fig.4 Resistance Comparision Graph

In Fig.4 resistance comparision graph is observed between Multi-harzard and Monte Carlo.

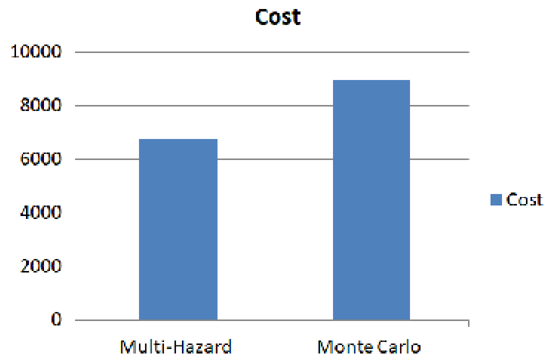

Fig.5 Cost Comparision Graph

Cost comaprision graph is seen in Fig.5. The graph is observed between muti-hazard and monte carlo.

V. CONCLUSION

Developing next-generation designs for sustainable, durable, risk-tolerant, resilient and intelligent building structures. It introduces the concepts and needs of sustainability, durability to multiple hazards, resilience, and monitoring and management in civil engineering for future structures, providing a good overview of related research and a vision for achieving these design goals. Effective data collection, civil infrastructures SHM and data interpretations model need to be implemented to prevent and mitigated harms posed by different kinds of hazards, improve structure flexibility and safety, support restoration of structure function, enable rapid response in maintenances decisions, and improve lifecycle performance of the structure.

VI. REFERENCES

[1] H.R.Pourghasemi, A.Gayen, M.Edalat, M.Zarafshar, J.P.Tiefenbacher, Is multi-hazard mapping effective in assessing natural hazards and integrated watershed management? Geosci. Front. 2020, 11, 1203–1217

[2] X.W.Zheng, H.N. Li,; Y.B. Yang, G. Li, L.S. Huo, Y.Liu, Damage risk assessment of a high-rise building against multihazard of earthquake and strong wind with recorded data. Eng. Struct. 2019, 200, 109697.

[3] Wallemarq, P.; Below, R.; McClean, D. UNISDR and CRED Report: Economic Losses, Poverty & Disasters (1998–2017); United Nations Office for Disaster Risk Reduction: Geneva, Switzerland, 2018.

[4] I.Venanzi, O.Lavan, L.Ierimonti, S.Fabrizi. Multi-hazard loss analysis of tall buildings under wind and seismic loads. Struct.Infrastruct. Eng. 2018, 14, 1295–1311.

[5] Elias, S.; Matsagar, V. Research developments in vibration control of structures using passive tuned mass dampers. Annu. Rev. Control 2017, 44, 129–156.

[6] Ettouney, M.M.; Alampalli, S. Multihazard Considerations in Civil Infrastructure; Taylor & Francis Group: Abingdon, UK, 2017; IRBS: 9781482208320

[7] Huang, M. High-Rise Buildings under Multi-Hazard Environment; Springer: Berlin/Heidelberg, Germany, 2017.

[8] Avossa, A.M.; Demartino, C.; Contestabile, P.; Ricciardelli, F.; Vicinanza, D. Some results on the vulnerability assessment of HAWTs subjected to wind and seismic actions. Sustainability 2017, 9, 1525

[9] Zaghi, A.E.; Padgett, J.E.; Bruneau, M.; Barbato, M.; Li, Y.; Mitrani-Reiser, J.; McBride, A. Establishing common nomenclature, characterizing the problem, and identifying future opportunities in

multihazard design. J. Struct. Eng. 2016, 142, H2516001.
[10] U.Barua, M.S.Akhter, M.A.Ansary, District-wisemulti-hazard zoning of Bangladesh. Nat. Hazards 2016, 82, 1895–1918.
[11] Aly, A.M.; Abburu, S. On the design of high-rise buildings for multihazard: Fundamental differences between wind and earthquake demand. Shock. Vib. 2015, 2015, 148681.
[12] Patil, S.J.; Reddy, G.R. State of art review—Base isolation systems for structures. Int. J. Emerg. Technol. Adv. Eng. 2012, 2, 438–453
[13] Kappes, M.S.; Keiler, M.; von Elverfeldt, K.; Glade, T. Challenges of analyzing multi-hazard risk: A review. Nat. Hazards 2012, 64, 1925–1958
[14] Jónsson, M.H.; Bessason, B.; Haflidason, E. Earthquake response of a base-isolated bridge subjected to strong near-fault ground motion. Soil Dyn. Earthq. Eng. 2010, 30, 447–455.
[15] Duthinh, D.; Simiu, E. Safety of structures in strong winds and earthquakes: Multihazard considerations. J. Struct. Eng. 2010, 136, 330–333.
[16] Kunde, M.C.; Jangid, R.S. Seismic behavior of isolated bridges: A state-of-the-art review. Electron. J. Struct. Eng. 2003, 3, 140–170.
[17] Spencer, B.F.; Nagarajaiah, S. State of the art of structural control. J. Struct. Eng. Am. Soc. Civ. Eng. ASCE 2003, 129, 845–856.
[18] B.K.Bhartia, E.H.Vanmarcke, Multi-Hazard Risk Analysis: Case of a Simple Offshore Structure; National Center for Earthquake Engineering Research: Taipei, Taiwan, 1988; p. 80.