



Improving disaster resilience through effective building code compliance

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Abstract

The paper aims to develop a compliance framework with the building code, regulation, and standards for a safer built environment. The purpose of this paper is to develop a framework that will improve and encourage effective building code compliance to achieve disaster resilience. The compliance framework aims to enhance the resilience of the built environment through an easier and practical approach to communicating and managing code requirements. The paper will examine the significant factors affecting code compliance with building code and why some parties find compliance challenging to achieve. The paper highlighted the significant factors affecting code compliance and why some parties find compliance difficult to achieve. The paper shows the main code compliance drivers amongst stakeholders and how an effective compliance process can be achieved by multi-party collaboration and simplification of building codes. This study have not tested the developed compliance framework. The applicability of the framework can be tested using different case studies. This is an original research that takes a unique look at enhancing compliance with building code, regulations, and standards by developing a framework to aid easy code compliance to achieve a safe built environment.

Keyword: Building code, Compliance, disaster resilience.



Introduction

The built environment has witnessed many disasters over the years, caused by nature or human-made. Building code regulation has been identified as a measure to reduce the impact of a disaster such as an earthquake causing destruction to buildings and infrastructure in the human environment. Building code exists in most countries that are prone to earthquake; however, building collapse still causes deaths and economic losses during an earthquake. Deficiency in compliance with code regulations has been attributed as the primary root of large scale deaths and property loss in recent disaster (Burby and May, 2000, Suresh, 2002).

The disaster inspired by natural hazard reveals a lack of compliance with the building code in the built environment (Ricciarini, 2009). Introducing and enacting building code into law is a pathway in the right direction that demands the sustainable participation of different stakeholders. Some of the countries in Asia, such as Bangladesh and Nepal that have building codes that lack the compliance application in reducing disaster (Ahmed et al., 2018). Non-adherence to compliance culture has been attributed to the low-income countries, which (Moullier and Krimgold, 2015) described that compliance criteria's in those countries are too high because of over-dependency on imported building materials. In many low-income countries, there is no integration among the major stakeholders involved in the building industry, which accounts for significant challenges facing enforcement and compliance (Moullier and Krimgold, 2015).

The benefits of building regulations in addressing the issue of disaster cannot be achieved without making the compliance documents of standards, codes and regulations to be user-friendly, easy to understand and a well-defined pathway to earn compliance. A made-easy procedure of compliance documents is necessary for rebuilding cities in the post-disaster reconstruction process.

This paper presents a unique conceptual compliance framework to achieve safer built environment, through providing a practical approach that will bridge the communication gap among the stakeholders, examine significant factors affecting code compliance, difficulties in achieving compliance criteria's, and outlined effective compliance process that will drive



resilience improved built environment. Moreover, the study presents voluntary compliance strategies embedded in enforced compliance to boost compliance willingness when implementing building code requirements. In conclusion, the study emphasised the need for extensive consultation among the regulators and the regulated.

The need for building code compliance

Disaster has presented itself as a threat to the existence of humanity in the built environment. The consistent occurrence of disaster has necessitated the quest to provide solutions to reduce the impact of disaster inspired by natural hazards in the world. In pursuit of this goal, the building code has been instituted to decrease the impact of the disaster. The building code is an effective tool to protect lives and properties to earthquakes, and it reduces community risks (Ainuddin et al., 2014, Dixit and Leon, 2009). Building codes are available in most countries, especially in countries prone to disaster; nevertheless, there is a significant loss to deaths and properties to disasters triggered by natural hazards as a result of building code non-compliance (Ainuddin and Routray, 2012, Bilham, 2009, Bilham et al., 2001, Gupta et al., 2006, Dixit and Leon, 2009). Jones and Vasvani (2017) pointed out that the enforcement of building code to achieve compliance in many countries is a significant challenge. Many low-income countries that seek to attract investors for rapid global growth do not allow strict enforcement of the building regulation acts (Spence, 2004). However, non-compliance with building codes and standards tend to limit the aim of building code as a measure that sets the minimum guidelines for any building. Building code practice can act as a source of disaster risk reduction only when adequate care and priority is given to code compliance with proactive enforcement.

Non-adherence to building standard is a global issue that has frequently shown up in the aftermath of most disaster events. This issue demands a rapid collective effort of all stakeholders to ensure that code enforcement will move beyond forcing people to comply, to voluntary compliance. Furthermore, it essential to understand that building damage during an earthquake is inversely proportional to appropriate building code compliance, quality of construction material, quality of design and construction, monitoring and inspection of the building during and after construction and willingness to regular compliance without policing enforcement.



Building code provides the minimum standards for the structural safety of the building, but this can be fulfilled through effective implementation and compliance with the code. Ainuddin et al. (2014) noted that poor compliance with the building code and inadequate construction practice exposes people to earthquake vulnerabilities. In 1992, a quarter of the total insured losses was attributed to constructions that did not follow the code standards during Hurricane Andrew by the insurance industry (Council, 1995). McGillivray (2017) claimed that 25% loss from Hurricane Andrew might have been prevented through strict code enforcement and compliance. Furthermore, the impact of the Northridge earthquake would have been reduced if the building code was adhered strictly (Burby et al., 1998a, Commission, 1995). The catastrophic nature of Gujarat earthquake was accredited to non-compliance and inadequacy for seismic safety regarding the building codes (Institute, 2002, Jones and Vasvani, 2017, Menum and Mistry, 2001, Mistry et al., 2001), while lack of building code enforcement and regulation was also mentioned (Yates, 2002). In countries like Nepal, building standards have started gaining more consideration after about 250000 buildings were destroyed by the 2015 earthquake (CHITRAKAR, 2015). Most recent disasters in Bangladesh and Nepal are significantly attributed to non-compliance to the building code (Ahmed et al., 2018). Scott (2013) pointed out that it will cost the government of New Zealand \$NZ 40 billion (\$34 billion) to rebuilding Christchurch, following the February 2011 earthquake that claimed 185 people lives. Negligence to building code compliance is the primary difference between the impact of 7.0 magnitude earthquake in the New Zealand and the Haiti, where the manageable earthquake hazard in New Zealand turned into a catastrophic disaster in Haiti (Ambraseys and Bilham, 2011, Hayes et al., 2010, Lindell, 2010).

It is clear that having building code without better enforcement and compliance, losses to disasters like an earthquake cannot be reduced. Poor compliance with the building code, low preparedness, and poor construction practice caused the demolition of ninety percent of buildings in Baluchistan (Ainuddin et al., 2014). The urban vulnerability is increasing with the construction of buildings that do not comply with the standards stipulated in the building code, especially (Quarantelli, 2003) as population density and assets increases in the urban areas.

The magnitude of disaster impact in any location is inversely proportional to the level of commitment to building code amendment, implementation, and compliance practiced in that



area. Effective compliance with building regulations has yielded a good result in disaster prevention and reduction of damages in the built environment. Maki and Hayashi (2000) stated that the rate of building collapse in Japan had been lowered significantly through regular codes amendment, enforcement, and compliance. The minimal destruction from the Darfield earthquake in 2010 showed how strict implementation and compliance to building regulations could help to reduce the impact of any disaster in the built environment (Gledhill et al., 2010, GNS, 2010). Better implementation of building code has helped in reducing the earthquake fatality nature in the last decades (Scawthorn, 2011). After the severe earthquakes in 2013 and 2015 in Nepal and Bangladesh, Ahmed et al. (2018) and Subedi and Mishima (2008a) reported an increasing culture of voluntary building code compliance within the municipalities and real estate developers. Existing design methods and building construction in Nepal were changed and improved following the destruction of the 1988 earthquake (Parajuli et al., 2000). The September 16, 2015 earthquake in Chile considered as the world strongest earthquake produced only 13 fatalities showcased the country's strict building code enforcement that requires all structures to survive a magnitude of 9 Mw earthquake without collapse (Nyachhyon, 2017). (Spence, 2004) highlighted that thorough implementation and application of building code have successfully reduced disaster in the built environment.

The need for building code compliance effort may fail due to lack of awareness creation to the code users, especially with the local communities, and lack of skillful technical staff with experience on how to let the code users see the importance of complying with new regulations. Educating and training the communities about the inherent risks and the significance of disaster-resilient structures is a step in the right direction towards achieving a compliance mindset among the code users. However, to achieve the need for a compliance mindset among the code users and local communities, efforts must be made to let the code users see the consequences of not complying with the building code. Building code compliance is one of the vehicles to drive the goals of the disaster risk reduction agenda in the built environment. The effectiveness of code compliance and enforcement mostly dependent on the commitment of each stakeholder in carrying out their respective tasks to ensure the voluntary participation of all code users, at all stages of design and construction. Furthermore, all stakeholders must be



involved to ensure adequate compliance with building code by setting out workable strategies to encourage local communities and code users to comply without hesitation.

The roles of stakeholders in code compliance

It is true that building code provides the minimum standard for the structural safety of buildings, but the choice to strictly comply with the guidelines stipulated in the code is what ensures safety. Improving the resilience of the built environment during and after any disaster like earthquake requires the participation of all stakeholders to enforce the building code and compliance documents. However, in most cases, there is disagreement among the stakeholders on what should be done to enhance building code compliance through improved enforcement (Burby et al., 1998b). Yates (2002) believes that only the government cannot enforce the building code in the system. Burby and May (1999) noted that the government had made limited attempts to influence the enforcement of building code practice. When all stakeholders fail to participate, it often results in lapses in enforcing building code which leads to the poor performance of structures during a disaster. Fostering better collaboration among the various stakeholders promotes mitigation for earthquake hazard structures. However, this requires attaching incentives to compliance. Although the stakeholders play different roles, it also requires communicative efforts within the stakeholders on how to carry out a successful building code enforcement in the construction industry. Figure 2 shows the role of stakeholders in ensuring effective building code compliance.

Policing enforcement of building code cannot result in effective compliance without providing adequate guidance on how to meet up with the compliance criteria's. Hence, the building regulators and other stakeholders must ensure that all code user understands the compliance pathways and criteria. Moullier and Krimgold (2015) stressed that the building regulators must develop engaging strategies to foster collaboration among the code user's to discuss their opinions. The collaboration must be carried out internally and externally to achieve expected results, as shown in Figure 1. The internal cooperation provides a platform for code user's to share and gain experience on how to achieve code criteria leading to compliance, while the external collaboration opens doors to share international ideas and knowledge as shown in Figure 1. The internal collaboration will help the regulators to have direct interaction with those



they regulate and finds ways to administer solutions to their complaints. Zaidi and Davies (2010) pointed out that lack of interaction among the major key actors in the building industry and active communication contribute to non-compliance to the building code. Moullier and Krimgold (2015) believed that open consultation gives an opportunity for stakeholders to offer views to the relevant authorities. However, in some cases, the relevant authorities neglect the views and opinions of the stakeholders and the public (Nyachhyon, 2017, Thiruppugazh, 2008).

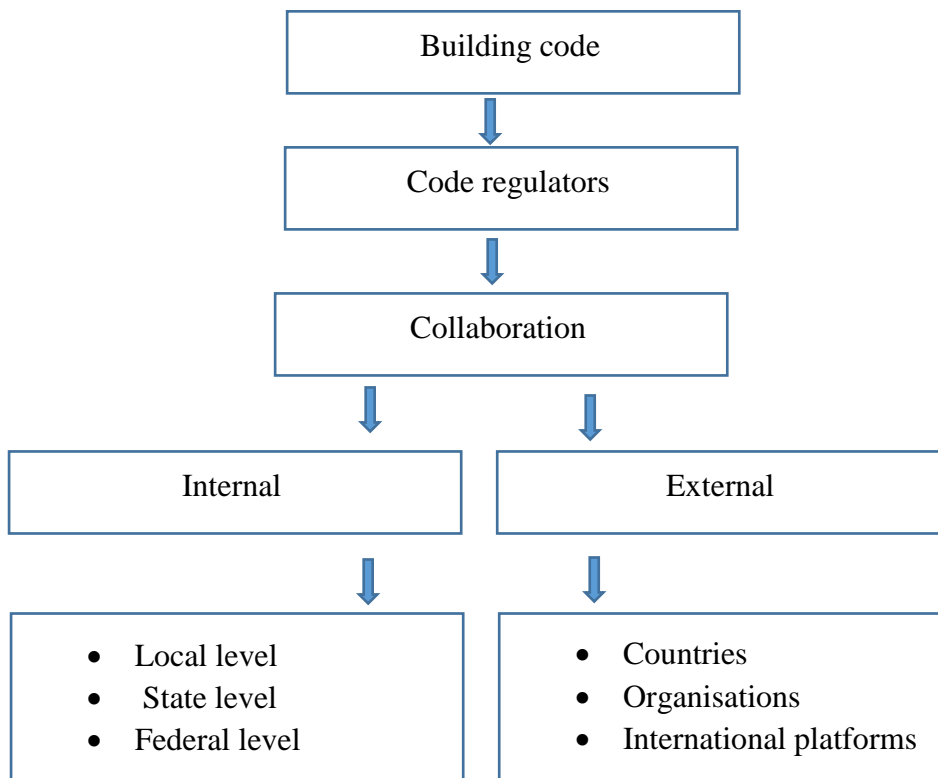


Figure 1: Internal and external collaboration

Nyachhyon (2017) opined that timely dedication on capacity building of local authorities, government and non-government organisations would have reduced loss of lives and properties in the course of an earthquake and other extreme loading conditions. Lack of capacity building shows the weakness of building regulators and the government in fulfilling the purpose of establishing building code regulations. It is the role of the government at all levels to seek



various ways of reducing seismic hazards vulnerability in the environment (Thiruppugazh, 2008). Such roles as initiating regular building code amendments, enforcement of the building code, enacting urban development bylaws, checking strength of old buildings, inspection of building construction and verification of building designs (Georgiou et al., 1999, Ilozor et al., 2004, Zaidi and Davies, 2010), should be giving top priority. Effective peer review of structural drawings before and during construction must be a significant factor to be considered because when the drawings are accurate, it paves the way for compliance. Nyachhyon (2017) believed that peer review of designs helps to reduce deficiency in reaching compliance. Transparency, accountability, openness, and efficiency should be seen in the activities of all stakeholders towards achieving compliance.

The construction industry, the government and the building regulators in collaboration with the professionals from the building industry must initiate a training platform to educate the practicing engineers, the technical staff of the local authorities and the entire code user community on the use of building code and various ways of achieving compliance. In most cases, the general public is ignorant of building code regulations and building planning schemes of their environment (Freiku, 2003, Owusu-Mensah, 2003, Somiah et al., 2015), which make it difficult to comply to the rules. Therefore, the general public must be educated to understand the importance of compliance with building regulations in significantly reducing the impact of a disaster and improving the safety of building occupants.

The need to improve compliance depends on the technical support skills of the building regulators and the construction industry professionals. Nyachhyon (2017) noted that an accurate interpretation of the building code aids compliance. However, this can be achieved when strict enforcement of building code specifications regarding verification of building design, an inspection of building construction and monitoring are given top priority. Although, without a proactive functioning regulatory process, the efforts of the technical staff cannot be seen. Spence (2004) stated the need for the government to step up their action on legislative enforcement of building code, knowing that (Clift, 1996) the quality of any structure depends on the magnitude at which the building meets the requirements of the building specification.

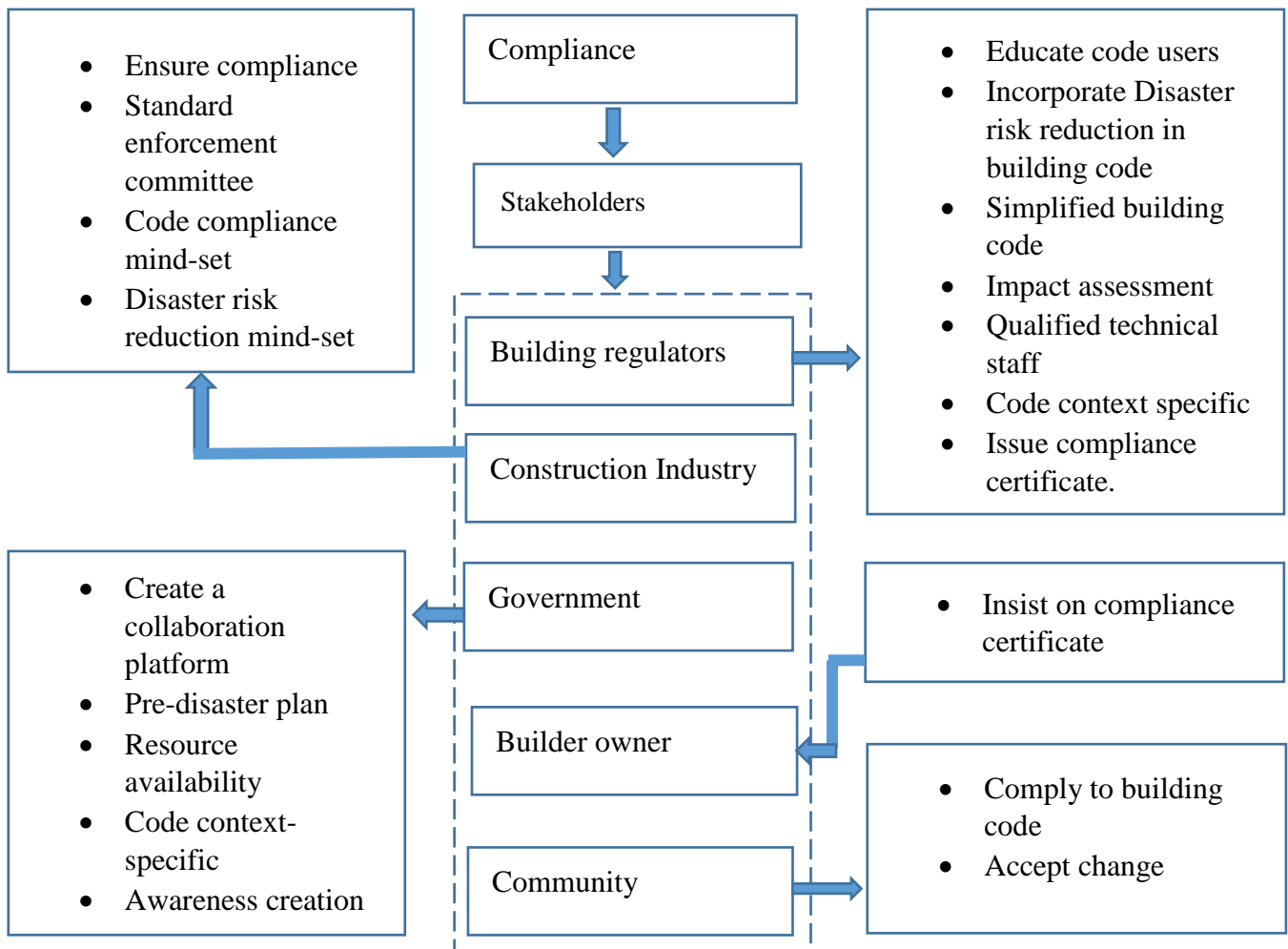


Figure 2: Stakeholders role in building code compliance

Effective Building Regulation Compliance

Building code compliance documents are written and enacted into law to be obeyed. However, research has shown that many code users do not conform to the regulations as stipulated in the building code, (Burby et al., 1998b) even though the consequences are calamitous in the built environment. Initiating compliance culture among the stakeholders is a direction in the right path that requires proactive sensitisation and awareness creation on the need to conform to the



building regulations among the stakeholders and the general public. Ricciarini (2009) critically outlined the process to achieve effective building code enforcement procedures, which inspires compliance. Although, Dixit and Esteban (2009) stated that building code compliance documents criteria's are complicated and not understood during implementation. Although, complicated building code may be safer to achieve a resilient environment, (Spence, 2004) stated that more straightforward codes are likely to be obeyed.

Effective compliance to building code demands sustainable capacity building among the enforcement agencies, the code users and the local communities. The building code compliance-capacity development must be regularly assessed to identify where improvement is needed, as shown in Figure 3. The capacity building on the part of the enforcement agencies must ensure to provide the viable knowledge needed for careful cross-check of design drawings, monitoring, and inspection during and after construction. The code users must be engaged and equipped on how to implement the building code requirements through proactive, practical oriented capacity development training. In addition, the local communities must be adequately informed about the importance of building code compliance, how to comply with the stipulated regulations and the consequences of non-compliance to their communities. However, the capacity building and the building code must be made country-specific to suit the environment where it will be applied. Bolger (2000) noted that the success of capacity building largely depends on the environment. Lack of capacity building and human resources are among the influencing factors that hinder building code implementation and compliance in Barbados (Chmutina and Bosher, 2015). According to Subedi and Mishima (2008b), capacity building should be able to include and address technical, financial and resource capacity.

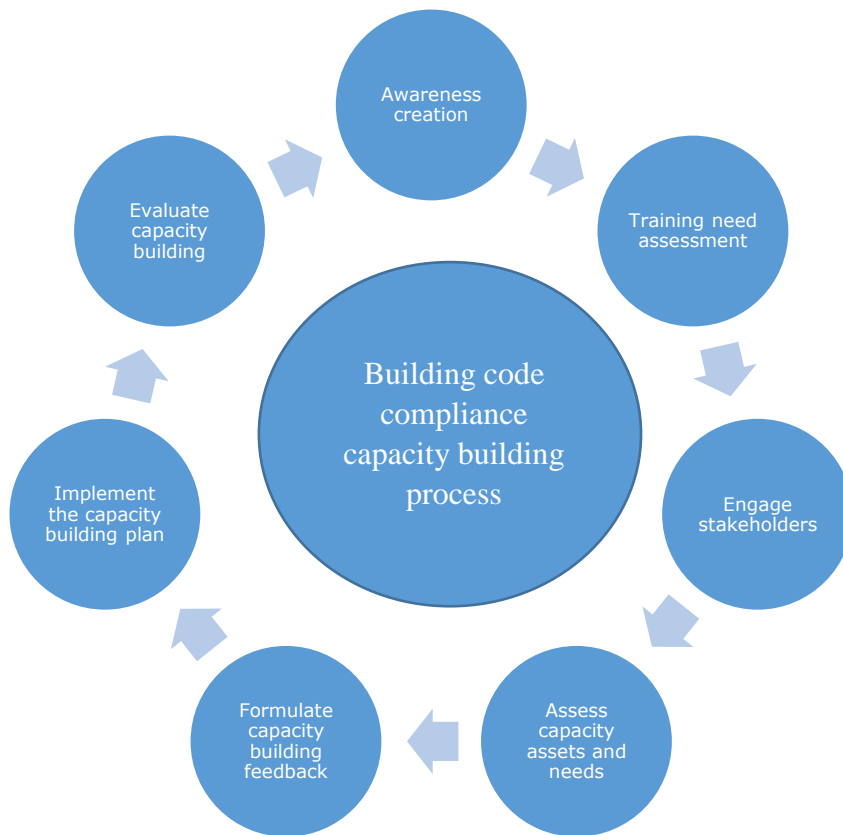


Figure 3: Modified Capacity building process for building code compliance (UNITED NATIONS DEVELOPMENT PROGRAMME (UNDP), 2009)

Building code compliance is directly proportional to capacity building, depending on the willingness of the involved stakeholders to accept changes and challenges associated with innovation. Awareness creation paves the road map to showcase the importance of conforming to building regulation, while the training need assessment will help to identify areas where adequate attention is needed. According to Kandel (2007) and Subedi and Mishima (2008b), awareness creation is the initial measure towards attaining building code implementation and compliance. Furthermore, the local communities and the regulated must be informed of the vulnerabilities of hazards in their environment to disaster and the dangers of non-compliance to building code (Suresh, 2002). Chmutina and Boshier (2015) opined that the people lack understanding of the significant role of building code compliance to the safety of their environment.



Building code enforcement: Effectuating the primary aim of building code regarding compliance requires both dynamic enforced and voluntary orientated strategies. The enforced compliance approach demands consistent surveillance and a more technically skilled enforcement task-force team while providing incentives that will persuade the building code users to attain compliance voluntarily. Some of these incentives can come as wavers to building permit fees and reduction in other related fees.

Although there have not been any generally accepted method of fostering voluntary compliance (Burby et al., 1998b), this study offers a broad strategy to improve voluntary compliance. This study suggests a mixed-method where voluntary enforcement can only be achieved through an efficient enforced compliance approach, which will, in the long run, create the willingness to comply, as shown in figure 4. The willingness to compliance will be driven when the penalty for non-compliance is much higher than the advantages of non-compliance. Long practice of strict enforcement of building code compliance creates the culture of voluntary compliance. However, adequate efforts should be made to train the code users, regulating agencies and the local communities to ensure a clear understanding of the building code requirements (Burby et al., 1998b). Kagan and Scholz (1980) believed that ignorance of regulations and incompetence are among the reasons for violation. Jones and Vasvani (2017) believed that a well-informed society regarding the level of risk and vulnerability have a higher tendency to comply with codes and pay for a safer environment.

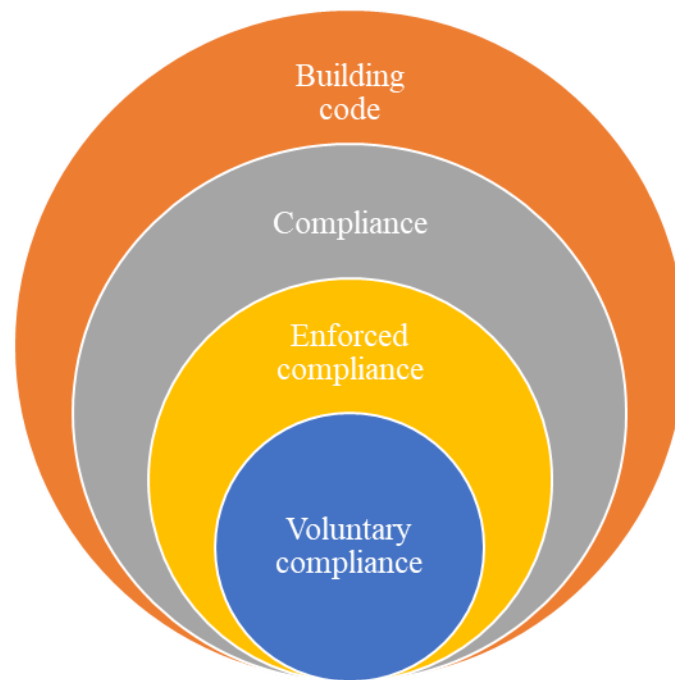


Figure 4: Fostering compliance approach with the mixed method

Proactive steps in educating the building code stakeholders, offering incentives, reducing the cost of compliance and pronounced punishment for repeated offenders foster voluntary compliance, as shown in figure 5. Punishment only does not achieve compliance (Moullier and Krimgold, 2015), but putting correction measures and implementing features of voluntary compliance does. Burby et al. (1998b) and Burby and May (2000) believes that the lack of capacity of the regulator's staff to detect violations and enforce compliance encourages non-compliance.

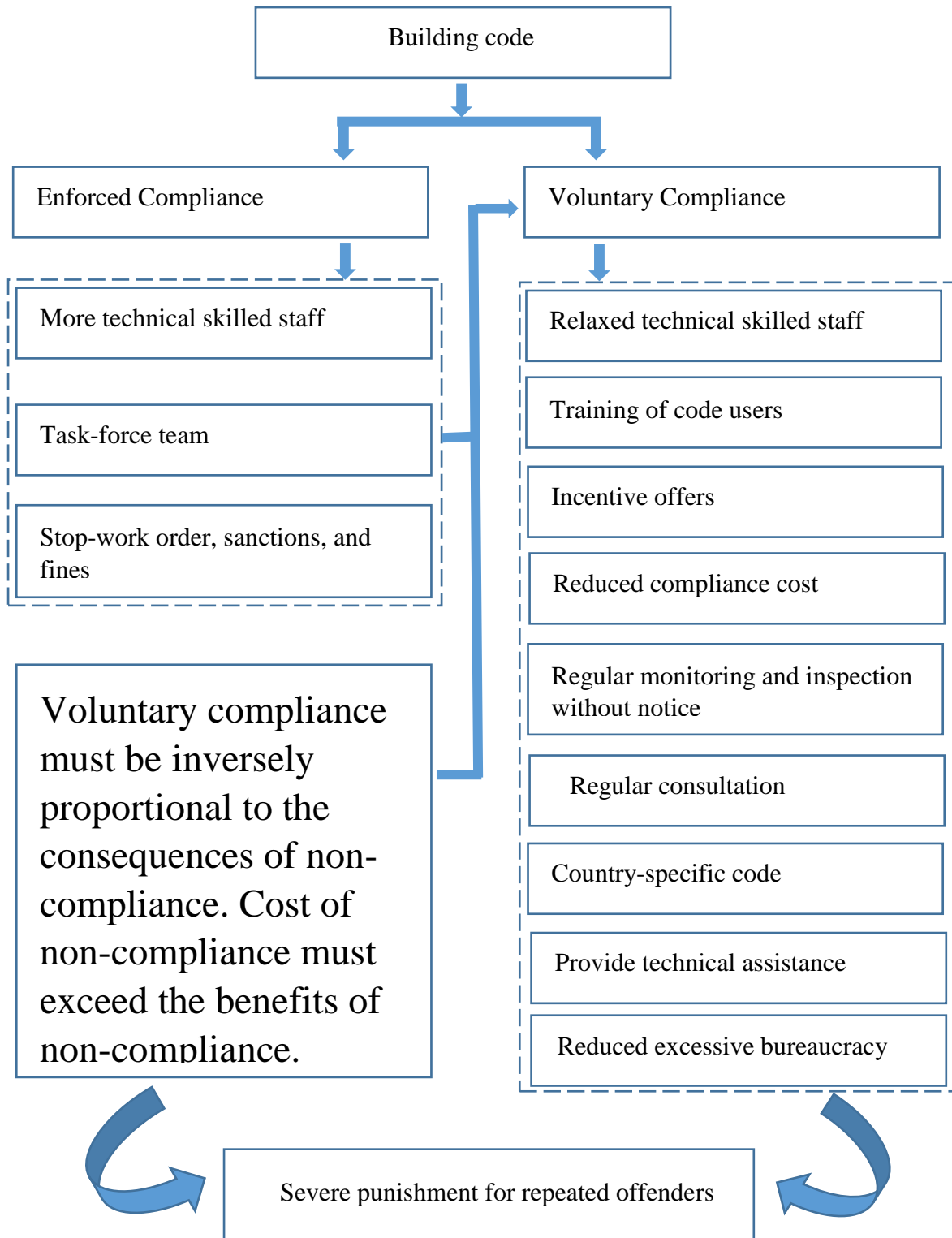


Figure 5: Features of Building code voluntary compliance



Balanced enforced compliance with proactive support of voluntary compliance features in figure 5 and compliance drivers in figure 6 will foster a sustainable willingness to voluntary compliance within a short period if adequately implemented. Voluntary compliance can be achieved when the regulated have to trust in the regulators (Moullier and Krimgold, 2015), on the platform of drivers of voluntary compliance. However, after active implementation of figures 5 and 6, repeated offenders should be severely punished to deter others from violating the aims of building code. Bloyd et al. (2013) strongly recommended that an open and transparent process will be imperative support in building code development, implementation, enforcement, and compliance.

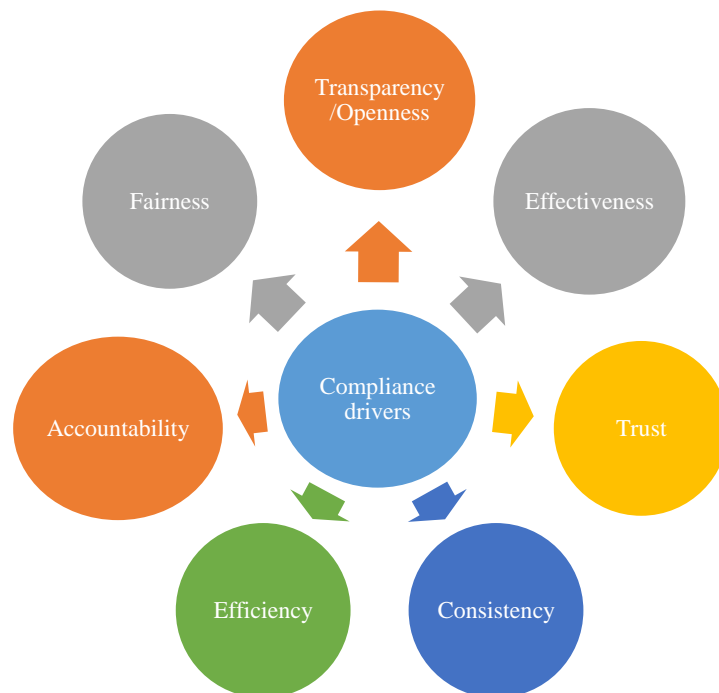


Figure 6: Drivers of Building code voluntary compliance

Factors affecting building code compliance

Building code compliance is of high-level importance in the construction industry as a result of efforts made to improve the resilience of buildings in the built environment. However, adherence to building regulations has turned out to be a significant challenge to the construction industry and other stakeholders. The efforts made by all stakeholders seem not to be effective



and efficient in many countries since the aims of building code have not been achieved in a wider scope. The factors affecting compliance with building code are always evident whenever there is an earthquake strike in the built environment. The issue of compliance with the building code never comes to the table of discussion except after an earthquake occurrence or other related extreme loading conditions. (Ahmed et al., 2018) reported that enforcement and compliance with the building code gained attention in Nepal after the catastrophic destruction of 2015 earthquake. The Bangladesh National Building Code (BNBC) was amended with efforts to enforce the new regulations (Housing and Building Research Institute (HBRI), 2015), following the 2013 building collapse of the Rana Plaza garment factory in 2013 (Business & Human Rights Resource Centre (BHRRC), 2013).

Unrealistic financial impact on compliance measures: Building code regulation in many countries is dysfunctional regarding compliance. In some countries, it is unrealistic to comply with the code regulations due to (Moullier, 2014, Moullier and Krimgold, 2015) cost of construction materials and unavailability of the materials within reach of the people. According to (Glenn and Wolfe, 1996, Mohammed, 1997), 75 percent cannot afford the cost of erecting a building in line with the building regulation in the Caribbean. Cost of construction material and the associated inaccessibility of the material leads to poor quality of material and construction (Goel, 2003; Spectra, 2002).

Corruption in building code enforcement process: Corruption among the enforcement agencies has turned many hazards to a disaster that leads to loss of lives and properties. Moullier (2014) noted that corruption in implementing, enforcement, verification, and inspection played a major role in the Turkey 1999 earthquake, killing 17000 people. Analysis from Sedlenieks (2004) revealed that corruption and dishonesty of regulatory officials in giving building permit and enforcement discourages the subjects from complying with the building code. In some countries, it is much easier to bribe the regulatory officials than to comply with the provisions in the building codes (Krimgold, 2011), even when regulated tried to comply, the regulatory officials frustrate their efforts. Weinstein (2008), demonstrated that affiliation of code users, building owners and the regulators with the political parties play an important role in frustrating in building regulation compliance in Mumbai, India.



Non-country-specific building code: Many low-income countries use building codes that are mainly adopted from western countries without streamlining it to suit their respective countries. Inadequate consultation of stakeholders, including the local communities before borrowing foreign building code has enhanced non-conformity with the building code and suffocate local technology. In most cases, building code borrowing does not recognise the traditional technology of the local communities, which leads to the fear of losing cultural heritage. Furthermore, Spence (2004) believed that copying code from a developed country to a developing country could compromise the implementation and enforcement process due to lower technical capacities. These make the building code to be more complex, non-user-friendly and non-compliable in reality.

Insufficient resource for enforcement and technical skills: Effective enforcement of building code requires sufficient financial resources and adequate technical skills of the regulators. According to Burby and May (2000), better enforcement guarantees the reduction of earthquake losses. Yates (2002) and Burby et al. (1998b) agreed that more violation detection strategies and the capacity to bring the violators to book are needed to effectuate compliance. This assertion holds because the offenders can only be punished if the system can detect the lapses. In some cases, there are technical skill regulators staff, but there is a deficiency in number to supervise the enforcement and compliance process.

Irregular update of building code and the associated compliance documents: Building code update is one of the fundamental pathways of achieving enhanced innovation and disaster risk reduction regarding resilient structures in the built environment. However, an irregular update of building code and the compliance documents can adversely affect compliance. In some countries like New Zealand, where building code amendment is done without any known interval, although, adequate consultations are made. The code users have to run with the pace of catching up any amendment, compared to countries like Australia, where building code is reviewed every three years. With this known interval, the regulated will not have to run to catch up with the updates.

Weak enforcement of building code: Enforcement of building code to reduce disaster has always been a problematic bottleneck on the regulator's side. Lack of enforcement of building



code in Nepal, Bangladesh and other countries have discouraged the regulated to comply with the regulations (Ahmed et al., 2018, Kandel, 2007, Yates, 2002), which limits the aim and objective of building code. Deterrence has been described as a motivating factor to activate compliance in any regulatory policy (Hunter and Waterman, 1992; Kagan and Bardach, 1982).

Socio-political context: In many cases, compliance with the building code is affected by social attitude regarding risk perception, trust between the regulators and the regulated and political policies of the government. The socio-political perception moves code users away or towards compliance, depending on the extent of the regulated trust the policy-makers. Lee (2008) noted that compliance with regulation greatly depends on the socio-political construct of the people. Effective compliance with building code demands that building code regulators must live up to expectations of the regulated and the host communities to earn their trust. In a social context, code user's reactions to comply with building code updates depend on the ability to interpret and understand the changes made to building code compliance documents. Although code user's actions regarding compliance to building code can be affected by the way, individuals perceive risk. However, awareness creation can help to propel people to see the importance of compliance and the devastating consequences, while increasing their risk perception and trust. The attitude of the authorities increases or decreases the risk perception and trust of the people (Terpstra, 2009).

Conclusion

Huge loss of lives and properties are always as a result of negligence in conforming to the stipulated regulations in the codes. To achieve the aim of building code in having buildings that are resilient to the earthquake and other extreme loading conditions, compliance with building code must be given adequate attention at all levels. Better understanding among the regulators, the regulated, the government and the general public is required to enhance compliance culture through proactive implementation of drivers and features of voluntary compliance as described in figures 5 and 6. Although the study encourages voluntary compliance, it also promotes severe punishment for repeated violators to serve as an example and deter others from the habit of non-compliance to building code. Embedding voluntary compliance into enforced compliance provides a holistic measure that will drive the designers



and the entire construction industry to a state of willingness to comply. This study provided a practical approach with a modified capacity building process for building code compliance in figure 3, to enhance the resilience of the built environment. However, the effectiveness of any building code is directly proportional to the positive attitude of the stakeholders regarding enforcement and compliance. Persuasive awareness creation, simplification of codes, trust between the regulators and the regulated and reduction of significant factors affecting code compliance are steps in the right direction in fostering a promising voluntary compliance culture.

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