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Research paper

Major barriers to the enforcement and violation of building codes and regulations: a global perspective

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Abstract

For centuries now, building codes have been a vital instrument for minimizing susceptibility to natural hazards. These codes are guides to architects and engineers when designing new buildings or renovating existing buildings in vulnerable areas. However, the productive implementation of building codes demands a good institutional structure and training of construction practitioners including artisan. This implies that the introduction of building codes and its proper administration will not be effective unless there is a strategic plan for its enforcement process. This is because the deficiencies and violations of building codes/regulations could lead to a large number of short-comings, particularly regarding the minimum requirements for public health, safety, general welfare, building quality and environmental protection. It is thus clear that there is a need to explore the barriers associated with the implementation and enforcement of building codes/regulations in different countries. This paper seeks to provide a better understanding on the major barriers to the enforcement and violation of building codes and regulations from a global perspective by reviewing building codes, exploring how they are enforced and the penalties for non-compliances in different countries. Finally, this paper concludes that some of the building codes and regulations are too complex for construction and building professional, and as such, many countries still struggle to understand the proper enforcement of building codes.

Keywords: *Building Codes and Regulations; Enforcement; Violation; Barriers.*

1. Introduction

Over the years, the importance of building codes has grown vividly, particularly with the advancement in the approach to its public awareness, needs, perceptions, trailblazing construction technology and new level of insights/knowledge in the construction industry [1], [2]. In spite of this great feat, building code development and implementation projects are faced with quite a number of uncertainties that are typically revealed at the appearance of potential faults [3]. Likewise, deficiencies and violations of building regulations can be recognized and tackled during the various phases of the development and implementation of a building code projects [3], [4]. However, since it is quite tough to address all difficulties associated with building code concurrently, it is crucial to detect these problems at the early stages and address them swiftly. This is because the public health, safety and general welfare implications of these problems could be quite huge [4].

According to the International Code Council (ICC), building code is a model code that provides minimum requirements to safeguard the public health, safety and general welfare of the occupants of new and existing buildings and structures [5], [6]. To buttress on the definition provided by the ICC, the Australian Government Productivity Commission [7], articulates that "building regulations may also be affected by building approval process, planning approval process, standard setting and accreditation of products, people and process, environmental regulations, occupational health and safety regulations". To reform building regulations in Australia, however, the Commission carried out a comprehensive study that organized and categorized the causes of the deficiencies of building codes based on four key functions that include administrative, legal, social and technical [7].

Nevertheless, with the difficulties involved in the development and implementation of the building code alongside the possible failure factors, organizations and institutions of building codes are often faced with enormous challenges when preparing to perform the task [4]. Besides, there is consensus among several building officials that their technical authorities do not fully have control over designs, construction documents, and construction inspection for every building and structure in most countries due to the lack of qualified personnel, tools, proper managerial system etc. [4], [7].

Several researchers and international government research bodies in the developed countries also agreed on the problem of inadequate implementation of building codes [7], [8]. For instance, a study by the Housing Association Property Mutual, United Kingdom, established that most of the building construction plans occurred as a result of failures to reach acceptable standards [9]. In a similar report by the Chinese's Ministry of Construction, it was established that only half of most of buildings that comply to standards on paper, do so in real

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construction [10]. Also, in an effort to prevent noise in educational buildings in France, researchers proposed a change in the acoustical standards [11], [12]. Likewise, Melo & Chapnik [13] also suggested the need to introduce structure-borne sound transmission (SBST) as part of the Ontario Building Code (OBC) in Canada. In addition, the USA Commission of Investigation recorded cases of waste, fraud and abuse of building codes in New Jersey cases of waste, fraud and abuse of building codes in New Jersey in 2005 that had inadequate and inappropriate construction codes alongside other deficiencies like corruption of inspections and code enforcement, inadequate consumer protection and restriction [14].

Despite the enormous research works that have been carried out, building and construction projects globally still suffer notable failures that are related to the lack of proper codes, deficiencies in meeting minimum requirements, and inadequate enforcement of new and existing codes/regulations [4], [15]. Moreover, preventing failure during the development and implementation of building code projects or resolving all problems associated with building codes is in no way simple, nevertheless a possible way to mitigate a number of these problems certainly exists at the same time.

There is therefore, a need to further explore the problems associated with the implementation and enforcement of building codes/regulations in different countries. This paper attempts to provide an improved understanding on the major barriers to the enforcement and violation of building codes and regulations from a global perspective. In an effort to achieve this, the current work aims at reviewing building codes, how they are enforced and the penalties for non-compliances in different countries.

2. Theory

2.1. Brief historic development of building codes

The existence of building regulations can be traced back to about 4,000 years ago [16]. Precisely, building regulations originated as far back as 1700 B.C. when the Babylonian Code of Hammurabi pronounced death penalty for any builders that is adjudged responsible for structural collapse that led to the loss of lives. [3], [17]. The protection of the health, safety, and welfare of the general public is the basis for permits for design professionals and the reason why building regulations are in existence. A few of the notable cases include [16]–[21]:

- Modern Era after the Great Fire of London in 1666: The rebuilding of London Act was passed as the first significant building regulation. Housing were required to have some fire resistance capacity and authorized the City of London Corporation to reopen and widen roads.
- 1905: The first National Building Code was published by the American Insurance Association. This provided the basis for testing procedures, conditions, and the arrangements of the codes use today.
- 1950: The fundamental Building Code that is presently known as the BOCA National Building Code published by Building Officials Conference of America (BOCA) that is now referred to as the Building Officials and Code Administrators International, Inc.
- 1994: The International Code Council (ICC) was established to develop codes that would have no regional limitations.
- 1997: The first edition of the International Building Code was published by ICC after three years of extensive research and development. The code was patterned on three legacy codes previously developed by the organizations that constitute ICC.
- 2000: ICC had completed the International Codes series that included the International Building Codes (IBC) and ceased development of the legacy codes in favor of their national successor.
- 2003 – Till Present: Updated editions of the International Building Codes are published on a three-year cycle following the first edition in 2000. These editions include the 2003, 2006, 2009, 2012, 2015, 2018. The current edition of IBC is the 2018 edition with the next edition coming out in 2021.

2.2. Code content and structures

According to the Council of American Building Officials, building codes is a family set of documents that usually comprises of four documents that include a building code, a plumbing code, a mechanical code and an electrical code [15], [22]–[24]. Building codes address the minimum standards necessary for new construction, renovation and repair of buildings. In some cases, the topics may include, but are not limited to, foundation, roofing, grading, structural support, ventilation, heating and air, electrical, plumbing and drainage, door or window replacement, electrical (i.e. wiring, lighting and service panels), fences and block walls over six feet high, mechanical (i.e. furnace or air conditioner replacement, replacing ductwork or fans), stucco/plastering, plumbing (i.e. hot water heater change outs, sink replacements, and re-piping), re-roofing with no structural alteration, installation of patio covers which do not result in the addition of a roof deck. Furthermore, like with the Building Officials and Code Administrators International's (BOCA) National Building Code that consist of 35 chapters which are classified into 11 sections. Building codes must be arranged and grouped in a logical format in an effort to properly address specific topics individually [4], [25], [26]. These sections include standards, occupant needs, building planning, administration and terms, fire protection, building envelop, building services, structural systems, non-structural materials, structural materials, special devices and conditions [4], [15], [26].

2.3. Application of building codes

Building codes have numerous uses and are mostly applied by engineering and architectural professionals. Other professionals that make use of building codes include manufacturers, contractors and subcontractors, insurance companies, oil and gas companies, safety inspectors, HSE professionals, real estate developers, and others [15]. Generally, once a building code is adopted as a law by the responsible government agency in a country, all construction events in the city, region or country are obligated to follow the building codes according to law. The administrative unit of the building code controls the permit and inspection process. Moreover, the building code offers standards for building design, building construction, and the maintenance for all categories of building and construction practices [27]–[29].

2.4. Management and implementation of building codes

Generally, the management of building codes involve two parts that include the issues related to the administration and enforcement of building codes and the implementation and enforcing requirements for design and construction. So, on one side, the first part deals with issues like licenses, permits, fees, inspections, certificates of occupancy, safety, projections beyond street lines, alterations, maintenance, applications, approval of drawings, stop work orders, and posting of building to indicate permissible live loads and occupant load [30]. On

the other side, the second part ensures that the appropriate standards are implemented for structural component, lighting, HVAC (Heating, ventilation, and air conditioning), plumbing, gas piping and fixtures, elevators and escalators, electrical distribution, stairs, corridors, walls, doors and windows [31].
However, the effective implementation of BC is dependent on a number of factors including the close involvement of key stakeholders in the development of the code. Likewise, a clearly defined control and verification system for assessing compliance that necessitates on-site inspection during and after the construction process and the adequate training of inspectors is also required. This should be supported by certification/energy rating of the building and penalties for non-compliance. In addition, building codes are often updated every few years taking into consideration the advancements in technology and construction techniques alongside knowledge acquired from natural hazards, terrorist attacks etc. [15].

2.4.1. Building permit issuing process

A building permit is a license which gives legal approval to construct or modify a building structure. Most codes require a building permit to be obtained before new construction or a substantial renovation can commence. Applying for a building permit is referred to as pulling a permit. Typically, only the owner of the real estate or a licensed contractor can pull a permit. However, the process of obtaining a building permit involves several stages from application stage, to the plans review stage, to the permit issuing stage, to the inspection of building.
Although there are standard forms for building permits in many countries, the issuance of a building permit may vary massively from country to country, district to district [19], [32]–[35]. Nevertheless, obtaining a permit is only half the battle. A building code enforcement inspector is required to carry out a thorough inspection to ensure that the work activities complies with the building code. If the construction does not meet up with the required standard, the inspector will indicate why the project doesn't meet the code, and the builder will have to remedy the issues to come within compliance [19], [32], [33], [35].

2.4.2. Site inspection

Carrying out site inspections help to safeguard the permit holder from deviating from the approved construction drawings and documents throughout the construction period [36]–[38]. In other words, the inspection of the construction works is carried out to authenticate compliance with the requirements of the contract documents. However, there exist three kinds of inspections managed by building departments and they include survey periodic inspections, complaint inspections, and called inspections. Normally, at least, there are five called inspection implemented throughout the construction period and they are foundations, footing, framing, concrete slab on grade, and final safety. In fact, called inspection demands that a cope of forms such as general inspection report, inspection record, job weather card, field correction notice, and notice violation must be filled [36], [38].
Conventionally on the larger projects, a site inspector is chosen to be the eyes and ears of the consultants and must be resident on site. They had limited power other than to inspect. Although they may condemn a work but it is the responsibility of the architect or the contract administrator to issue any instructions regarding such issue [37]–[39]. In some cases, specialist inspections may also be necessary for specific aspects of a project in required these may include the client's environmental policy, site waste management plan, accessibility, and so on.

2.5. Building department (BD) operations

According to the National Planning Policy Framework (NPPF), building department is defines as "the public authority whose duty it is to carry out specific planning functions for a particular area." The Building Department is usually the planning department and a law enforcement agency in a local jurisdiction or district council. Its major role is to enforce building codes. The size of BD varies from country to country and from city to a city [15].

2.5.1. Main workers/officials of building department

The major personnel of building department are generally a director of code enforcement, plan assessors or examiner, and building inspectors [40]. Typically, local governments entrust a director of code enforcement with the duty to ensure that building codes are enforced with a key task to protect public health, safety and welfare through the prevention or correction of code violations.
In addition, the plan assessors or examiners carefully peruse proposed construction documents for the compliance of building codes and regulations. The plans are frequently assessed to check some or all of the aspects of construction/building project depending on the scope, involvedness of the projects, and required code. Building inspectors on their part impose related design regulations, construction codes and regulations, and use of buildings. They also check the procedures and materials utilized in both existing and new construction structures [40].

2.5.2. Responsibilities of the code official

Basically, code official appraisal building applications and oversee primary inspection of new equipment installation and construction. Their responsibilities further include the issuance of permits, performing plan review, performing periodic inspections, and enforcing compliance with the code and related regulations [41]. In addition, they assess the services required, and estimate the cost of plan review and inspection of a building. They also assist in the preparation and management of budget for the building inspection division/department [41]. Ideally, they are required to oversee the final inspection for construction projects at completion for issuance of certificate of occupancy and signs for Building Inspection Division. Building code officials or inspectors visit and confirm that existing or new structures are safe, and that they are in compliance with federal and local codes, contractual specifications and zoning laws [41].

2.6. Code selection and compliances

Codes are normally implemented via model code organizations. Codes proffer environmental consistency and compatibility between the units of a political terrestrial region. It eradicates inexcusable preventive requirements and proffers uniformity, timely, and suitable reception of new products, approaches, and technologies [18]. Codes set up the ground for education and certification of building officials and proffer valued resources that yield technical information for professionals in the construction industry [18].

Moreover, researchers have put in place a number of principles that are required to formulate building codes and regulations [18]. The principles include the following according to the Building Research Establishment in 2008 [18]:

- The application of codes must be easy;
- For the different types of buildings and systems, codes must be applicable;
- Codes must be satisfactorily flexible to admit new technologies and design approaches;
- The enforcement of codes needs to be easy and reliable;
- The application of codes must be able to yield reliable outcomes;
- The must be consistency in the application of Codes;
- The application of codes must be able to differentiate between healthier and less decent buildings;
- Codes are expected not be have contrary side effects such as health or safety.

2.7. Standards in codes

Standard is referred to as a published technical document that signifies an industry agreement on how a material or gathering is to be designed, manufactured, verified or installed in order to reach a particular level of performance [42], [43]. Standards differ from codes and are not enforced by laws like codes. Generally, once codes are accepted by an authority, they turn out to be the prime authorities of references. While standards on the other hand are subordinate authorities of references. Ideally, standards provide specifics regarding design and engineering necessities, installation procedures, testing practices, or construction materials [42], [43].

2.8. Major code organizations in the world

There are a number of code organizations in the world that develop and publish standards associated with building. Most of these organizations regularly put together building codes for their countries while some generate model codes and provide the opportunity for other countries to champion their code knowledges [42], [43]. Of all these organization, International Code Council (ICC) is the organization that is mostly well-known for its widespread services for other nations. Another popular organization is the Building Officials and Code Administrators International (BOCA) which is a member of ICC that proffers services for code users [6]. BOCA provides services that include training and professional development, clarification services, documentation for code officials, plan review services, national representation on standards writing agencies, publication of professional journals, and so on [6]. The members of the major code organization typically include design and construction professionals, fire officials, building officials, building materials manufactures, distributors, and trade associations [6]. Other international code organization include but not limited to [6], [42]:

- The International Conference of Building Officials (ICBO)
- The National Research Council, Canada (NRCC)
- The Southern Building Code Conference International (SBCCI)
- The Australian Building Codes Board, Australia (ABCB)
- The National Institute for Land and Infrastructure Management, Japan (NILIM)
- Building Control, England, Wales and North Ireland, UK
- The Building Industry Authority of New Zealand (BIA)
- The National Office of Building Technology and Administration, Norway (NBTA)
- Illuminating Engineering Society (ILS)
- National Fire Protection Association, USA (NFPA)

3. Major problems associated with building codes in selected countries

Over the years, there have been pressing concerns about the construction industry globally that has led many countries to review a series of reports in an effort to identify the need to change their existing building regulations and its enforcement [44]. This is also geared towards solving and accommodating the construction difficulties and needs of these countries. This section will thus try to exemplify the major problem associated with building codes in selected countries by exploring the problem of deficiency in enforcement of building codes in selected countries, the problem of inadequate building codes and regulations in selected countries, and the problem of violation of building codes and regulations in selected countries.

3.1. The problem of deficiency in enforcement of building codes in selected countries

Over the past three decades, there have been consensus among many researchers and government research bodies on the challenges related to the deficient enforcement of building code [4], [18], [21], [28], [44]–[46]. Some researchers believe that there exist some barriers to the enforcement of building codes or regulations for residential construction that often do not get required engineering attention regarding the wind load requirements and other external factors for building codes [29], [45], [47], [48]. Others believe that building regulations are mostly too complicated for many parts of the building industry, and as such, many construction industries struggle to understand the need for building codes, particularly, in the least developed countries [49-51]. This can be traceable to the fact that corruption in the enforcement of building codes has been linked with widespread building failure and loss of life in disasters [49-51]. This is depicted in the evidence from recent statistics that indicate that 83 percent of all deaths related to earthquakes in the last three decades or more have happened in countries considered to be the most corrupt nations [49-51]. According to Building Research Establishment [52], [53] many countries have problems with quality of enforcement of building regulation. Nevertheless, the problem of deficiency in enforcement of building code slightly differs from country to country [49-51].

In Jamaica for instance, research has shown that 85 percent of the population cannot afford the housing units that conforms with the nation's present formal planning and building standards and this has led this group to ignore the enforcement of building standards in their buildings [54].

In one of the notable works on the problems of deficiency in enforcement of building code, Udoeyo & Ugbem [55] in 1995 indicated in their findings that poor inspection enforcement in the course of construction in Nigeria, are among other factors that was accountable for geometrical deficiencies influenced by disparities in geometrical quantities of reinforced-concrete members on three huge project sites [55].

Similar to the case of Jamaica, recent estimation shows that over 80 percent of the population of Trinidad and Tobago can afford the median price of $21,500 for a housing unit that conform to the current formal building standards of the nation [49]. This has however led to the creation of cities with established two-tier systems, wide social disparities, and preventive advancement on risk reduction [49].
Furthermore, in an investigation on the most noteworthy breach of code enforcement executed over a 12 years period, the Code Compliance Task Force, USA confronted the problem of an enormously high rate of examination failure rate, which amplified both the cost of reviews and time of inspection response to customers [56]. In addition, as part of the group that took part of the investigation, Fang and Okada [57] in 1999 projected that healthier building code compliance and enforcement possibly will have put a stop to 25% of the losses sustained from Hurricane Andrew, that strike Southern Florida (south of Miami) sometimes in August, 1992 [57].
In Canada, a study carried out by Rousseau [58] in 2000, demonstrated that low quality buildings products could be traced to poor building codes enforcement [58][50]. The author in his findings also discovered that most of the high-rise residential buildings need widespread expensive repairs while they are still moderately new [58].
In the UK, the Building Research Establishment [52], [53] revealed that the compliance of energy regulation was one of the feeblest areas in the enforcement of building codes. This they believe is traceable to perception that officers will not refuse certificates or arraign for catastrophes in this area, which has in turn resulted to the absence of respect for the regulations by builders [49-51], [53].
In Turkey, McPherson [59] suggested that there is an excessive negligence on the part of building officials to regulator construction [59]. The author revealed that day-to-day supervision are largely left to the site professionals and this is common across Turkey building regulation and planning system based on permits and local authorities [59].
In Australia, inadequate building codes are perceived to be a major factor that influence poor quality of residences, such as thermal and waterproofing and sound proofing standards [60].
In China, 60 percent of buildings abide by the building regulation on paper but only half of this group abided by the building regulation in real construction [61]. This is according to the China's Ministry of Construction report [61].
In India, there is a huge scale of defiance of building codes by the developers and builders in the private sector that is traceable to the existence of self-regulation system [62]. For instance, the failure of buildings in Ahmedabad is ascribed to insufficiency for seismic safety and violation of building regulations/codes, inferior construction and coldhearted contractors and builders, and deficiency of regulation and enforcement of building codes, low quality of construction and deprived quality of material [62].
Between 2003 and 2005 in the Netherlands, it was discovered that only 12 to 16% of municipalities properly executed authority of building permit applications and only 7 to 11% sufficiently executed authority of construction work. This is primarily related to the problem of understaffing [63]. It is thus clear that the problem of deficiency in enforcement of building codes varies from country to country.

3.2. The problem of inadequate building codes and regulations in selected countries

In an effort to understand the problem of inadequate codes and regulations in selected countries, a number of prior works by researchers and government research bodies in these countries were reviewed. The problem of inadequate building codes in Pakistan was realized during the 2005 earthquake, where most of the structures suffered some damage, but very few collapsed [64], [65]. Donors were primarily reluctant to support the construction method associated with the aftermath of the disaster due to the fact that there was no building code practices in place [64], [65].
In UAE, the fire and life safety code in 2013 was changed due to previous fires in high rise buildings; setting stricter requirements to the fire performance of external cladding material. The government saw the need to add sufficient codes so this matter related to this wouldn't reoccur [66].
In Turkey, the authorities realized there is a lot of inadequate building codes that have to be improved upon, following the 1999 earthquake in Kocael [67].
In Canada, Melo and Chapnik [13] in 2001 established the inadequacy in the Ontario Building Code (OBC) as regards the absence of structure-borne sound transmission (SBST) in the codes [13].
In the UK, a study by Housing Association Property Mutual [68] in 1997 established that most of the building construction defects happened as a result of the failures to accomplish acceptable standards [68]. In another study by Deakin [69], the author indicated that UK buildings are confronted with the absence of obvious safety measures [69].
In Brazil, Carvalho et al. [70] established that the rigorous use of masonry as structural material, the parameters and requirements attention of architectural design grieve by the inadequacy of requirement of conceptual design standards, and procedural codes [70].
In the US, there have been some current development regarding the wind load design requirements of the American Society of Civil Engineers Standard. This is as a result of the expensive losses which occurred to buildings as soon as the mechanisms of the external walls and claddings failed [71].
In Nigeria, Ayininuola & Olalusi [72] explored the failures in common buildings in Nigeria [72]. Like in some other industries [73], the survey research sponsored by UNESCO revealed that owners, designers, and contractors blamed building officials for the construction failures, particularly, for not following specified principals before and after building permit approval [72]. The authors in their findings further established that the major cause of building failures can be attributed to the absence and lack of enforcement of building regulations, codes, bylaw and construction health and safety rules [72].

3.3. The problem of violation of building codes and regulations in selected countries

A study conducted in 2005 by International Code Council on building code violations for building safety week survey, saw the participation of more than 400 code officials around the world [74]. The code officials that took part of the survey recorded the most common code violations to be: structural and wood framing problems (30%), grading, foundation, footing and concrete problems (24%), and exit (egress) was also noted (11%), especially problems with stairway handrails. In existing homes, the most common code violations were found to be electrical problems (15%), structural and wood framing violations (14%), and exit problems and fire safety related issues (13%) [74]. The survey also looked at top code violations in new and existing buildings and found that in new buildings the top violations were structural and wood framing problems (24%), permit protocol violations (16%), and egress concerns (15%). In existing buildings, the most common violations were egress concerns (21%), fire-related violations (17%), electrical violations (12%) and administrative problems (12%) [74]. The study also found that a large population of those surveyed is unfamiliar with all the requirements for sprinklers in new and in existing homes and buildings [74].

Furthermore, in the UK, studies conducted by researchers at the Building Research Establishment for houses under construction have established that approximately half the hundreds of identified faults are ascribed to improper design, violations of building regulations, codes and standards cited in building regulations, and codes and standards not cited in building regulations [75].
In Canada, the violations of building codes are punishable by law. For example, an owner of an apartment building was fined $18,750 in court for sprinkler system violations [13].
In the US, researchers have also shown that the violation of codes is a punishable offence under the law because of the related consequences [14]. For instance, a study reported that the violations of building code related to Minimum Roof Weight-Bearing Standards could influence hazardous occurrences, and significantly minimize the lifespan of buildings [14].

4. Conclusion

Following the relevant review of the related literature on the major problems associated with building codes in selected countries, the objective of this paper has been successfully achieved. As discussed previously, building codes and regulations are not free from flaws in spite of its effective enforcement in the developed countries like the US, UK, China, Australia and so on. This implies that there are still problems that can occur even if the country has standardized building codes/regulations.
Furthermore, it can be observed from the literature that the lower-class in many countries are not able to afford to settle in standard houses. This is traceable to the fact that houses built based on building codes, regulations, and standards are not cost effective and this is because they are built with costly and valuable material following specific regulations. Also, it was discovered from literature that there are some countries that have design building codes and are yet to implement and enforce the codes. According to literature, corruption in the enforcement of building codes is linked with widespread building failure and loss of life in disasters and interestingly, majority of the deaths related to earthquakes have occurred in countries considered to be the most corrupt.
In addition, there are some reported cases in the literature where some developed countries had to periodically modify or update the regional or state building codes any time there is a void that might be due to some external factors. Another major problem observed is the lack of follow up mechanisms that may be due to issues related to the government policies or understaffing (sometimes there are not enough personnel to inspect buildings or to adhere to the law which makes it difficult to enforce BC).
To summit on this, one can argue that some of the building codes and regulations are too complex for construction and building professional, and as such, many countries still struggle to understand its need, particularly, in the least developed countries.

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