



Development of an object model for automated compliance checking



Sagar Malsane^a, Jane Matthews^{b,*}, Steve Lockley^a, Peter E.D. Love^c, David Greenwood^a

^a The Faculty of Engineering and Environment, Northumbria University, Ellison Building, Newcastle-upon-Tyne NE1 8ST, UK

^b Department of Construction Management, Curtin University, GPO Box U1987, Perth, WA 6845, Australia

^c Department of Civil Engineering, Curtin University, GPO Box U1987, Perth, WA 6845, Australia

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ABSTRACT

Building designs in countries such as the United Kingdom are currently checked manually against a frequently changing and increasingly complex set of building regulations. This is a major task for designers and those bodies that are charged with enforcing the building regulations. As a result this can often lead to ambiguity, inconsistency in assessments and delays in the overall construction process. As the Architecture, Engineering and Construction (AEC) industry moves from 2D Computer Aided Design (CAD) drawings to more semantically rich Building Information Models (BIMs), the development of automated compliance checking systems for building regulations becomes achievable. A format well suited to the automation of compliance checking is that based upon Industry Foundation Class (IFC). IFC has been accepted worldwide as an inter-operability standard. However, whether the IFC data format can fully support the specialised needs of the England and Wales Building Regulations is still debatable. In order to automate their checking, building regulations first need to be interpreted from human-readable free text rules into a set of computer-implementable rules. This paper reviews previous research into automated code compliance-checking, identifies the key issues for future development, and focuses on the analysis of the England and Wales Building Regulations that relate to fire safety for dwelling houses, to determine and subsequently optimize the potential for automated compliance checking. Subsequently, a Building Regulation-specific, semantically rich object model, appropriate for the requirements of automated compliance checking has been developed for England and Wales.

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1. Introduction

With the arrival of Building Information Modelling (BIM) software, automated compliance checking of building designs using model checking software (MCS) is becoming a realistic prospect [1]. It is likely that in the near future BIMs will become important digital assets that are not only key instruments in communicating design, but also in obtaining approval from statutory bodies [2]. However, automated compliance checking requires the application of software tools (which are normally generic and international) to codes and regulations (which are specific and local). To date, the strategy adopted in most compliance-checking initiatives has been to convert proprietary BIM models into the international standard format, namely, Industry Foundation Class (IFC), and then to author bespoke compliance rules that can be executed using this model.

One of the problems with this approach is that often BIM tools are not designed to populate these IFC models with all the data required for checking compliance; BIM tools normally target and cater for an international and general customer base and therefore struggle to accommodate the nuances of specific and local building codes and regulations. In addition, there are many basic concepts within the

Building Regulations, such as the space classification “habitable room” which exist in complete isolation from established classification standards such as Uniclass and Omniclass. It may therefore be impractical to expect the authors of BIMs to explicitly define all the information required to check for compliance, particularly where this information is only relevant to the Building Regulations. Thus, for reliable compliance checking, it is likely that additional data will need to be provided by the design team as a separate activity.

Against this contextual backdrop, this paper defines, within the IFC model, a domain extension for the England and Wales¹ Building Regulations building on the existing work of the buildingSMART International [3]. Working with the National Building Specification organisation (the official publishers of England and Wales’s Statutory Requirements, in the form of the Building Regulation Approved Documents) concepts, objects and properties that are entrained in the Building Regulations (England and Wales) have been identified and formal syntaxes for the creation of the requisite rules are explored.

The England and Wales Building Regulations ‘Approved Documents’ consist of clauses that are written in a natural linguistic format. They set out the standards that ensure building works are compliant [4,5].

¹ It should be noted that England and Wales have different building regulations to those established in Scotland and Northern Ireland.

* Corresponding author.

Examples of the characteristics that typify these Building Regulations include:

- Their subjective complexity;
- Their inconsistent use of terminologies; and
- The complexity of their structuring and inter-relationships.

The above characteristics make the checking of building designs for compliance a complex and time consuming activity, prone to human error and dependent on the building inspector's experience, judgement and skills. They also, by their nature, make the transition to automated compliance checking a difficult process. Thus, details of the development of a Building Regulation-specific semantically rich object model, appropriate for the requirements of automated compliance checking, through leveraging object oriented BIMs coupled with the IFC as an interoperability standard, are presented within this paper.

2. BIMs and IFC

To create a BIM, a modeller uses semantically rich objects to build a virtual prototype. Recent developments in both software and hardware have resulted in significantly increased sophistication in representing building models. The resulting object-oriented models have a key advantage over traditional 2D drawings, in that they are computer interpretable. This, coupled with the ability to attach an extensible set of “properties” to objects means that the use of BIM is potentially a far more convincing instrument in communicating building designs in terms of obtaining sanction from the rule-checking authorities [7]. However more often than not a building model does not typically include the detailed level of information required for fully automated rule checking.

Even when semantically rich BIMs are available the full benefits will materialize only through sharing of information contained within them across organisations, departments, information technology systems and databases [8–10]. The IFC data model, developed and maintained by buildingSmart International, is the key to facilitating this interoperability in a cost-effective way and without relying on any particular product or vendor-specific file formats [11,12]. IFC adds a common language for transferring information between different BIM applications whilst maintaining the meaning of different pieces of information in the transfer [6,13]. The IFC data model is registered as an International Standard by the International Organization for Standardization (ISO) as ISO/IS 16739 [14] and is implemented in all the major BIM packages, which can consistently export valid IFC data files describing a building design, including the model hierarchy, properties and behaviours of building objects. The IFC is suitable in terms of standardisation, unambiguity, consistency and completeness of description of building designs. IFC's significance is further acknowledged on the basis of its use on existing code checking projects [6].

3. Existing strategies and approaches to system development

A detailed review of the rule checking systems that have been developed to assess building designs according to various criteria can be found in Eastman et al. [6]. To provide a context for the research reported in this paper, a brief review of the various rule based applications for model checking is presented hereinafter.

3.1. Singapore (CORENET)

The 'BP-Expert' system has been available in Singapore from as early as 1995 for checking 2D drawings with a view “to reengineer and streamline the fragmented work processes in the construction industry, so as to achieve quantum improvements in turnaround time, quality and productivity” [15]. In 2000 it was replaced by 'e-PlanCheck' as part of the Construction and Real Estate Network (CORENET) project [16]. CORENET ePlanCheck was one of the first initiatives developed

for automated code-checking, and was funded by the Singapore Ministry of National Development and carried out by the Construction and Real Estate Network [16]. This aimed to provide an internet-based electronic submission system for checking and approving building plans. Building proposals were submitted as a combination of existing 2D drawings with additional information provided in supplementary IFC-based files. The system was considered to be ‘cutting edge’ and conceptually strong, yet there is little evidence of continuing work on the specific initiative.

The aim, as before, was to improve performance, increase coverage and check compliance of building data in an IFC format. However, as long as the implementation of the IFC by CAD vendors remained focused on geometry many of the requirements for compliance checking were not available. ePlanCheck addressed this by commissioning an independent platform, FORNAX, which originally sat on top of the already existing Jotne EDMModelChecker (EDM Checker), but later evolved to encompass a rule checking engine, which therefore relinquished the need for its use. FORNAX is an object library written in C++. Each object contains all the relevant attributes for the Singapore codes as well as the rules that apply to that object. Each object is designed to be extensible in order to cover the requirements of other countries, and as a result CORENET ePlanCheck was used as the basis for pilot projects in Norway, and New York [17]. Despite ongoing attempts to implement code checking, reported difficulties with verifying data quality [18] and its inability to support the checking of design standards throughout the different design stages of the project (in contrast to systems such as DesignCheck below), ePlanCheck in Singapore is still the only system that is currently operational, albeit currently developing at a very slow pace whilst waiting for the industry to catch up with the use of BIM [13].

3.2. Norway (Statsbygg)

The CORENET ePlanCheck work was developed and emulated in Norway with the ByggSok system [19]. This is an e-Government system comprising three modules: an information system, a system for e-submission of building applications and a system for zoning proposals. Driven by the Norwegian Building and Construction industry and supported by Standards Norway and Norwegian BuildingSMART it is heavily based on IFC standards. The work is ongoing and currently focussing on the issues of classification, terminology and standardising rule-checking in construction at an international level.

Building upon their e-PlanCheck pilot projects Norwegian developers Statsbygg have experimented with multiple systems as part of their efforts to extend the use of IFC based BIM to the entire project life cycle. The resulting systems have been piloted on real projects, with data being exchanged through a wide selection of software to suit the various stages/tasks of the project lifecycle. On the HITOS pilot, the code-checking efforts have focused predominately on accessible design. Here the building model data are stored and accessed through the EDM Model Server in IFC format. The accessibility rules are parameterised, mapped to their associated building objects and executed using Solibri Model Checker's 'Constraint Set Manager'. Solibri communicates directly with building model data in IFC format, but retrieves only the objects it needs – in this case those mapped to the accessibility rules. The rules implemented to date focus predominantly on geometrical constraints and as such the objects and parameters are supported by the IFC data models produced by current BIM packages.

The Statsbygg Solibri system does not support the enhancing of these data models or the export to IFC format, and so cannot currently be used for compliance checking of attributes not supported by the current BIM vendors. The Solibri Constraint Set Manager is implemented in Java and comes with a library of built-in parameterised rules which can be configured by adjusting the parameters. Any new rules, however, must be custom-made in collaboration with the Solibri software developers and, as such, are not easily adapted for other

software. Solibri has the benefit of a powerful 3D modelling engine which, in combination with the ability to directly read IFC files, allows for clear visual reporting of rule infringements for the user. In addition, Solibri's built-in rule library contains rules for validating a data model prior to rule checking, which is useful.

3.3. Australia (DesignCheck)

Both the Solibri Model Checker and Express Data Manager (EDM) have been considered as possible platforms for automated code checking in Australia; again focusing on accessible design regulations [6,13]. However, the research undertaken by Ding et al. [13] used EDM to create 'Design Check', which uses object-based rules. Building data models, in IFC format, are imported into the EDM database and transformed into the DesignCheck internal model. The DesignCheck model includes building code specific information not currently implemented by BIM vendors.

A mapping schema, written in ExpressX translates the building data model from IFC format into the DesignCheck schema. The strategy is similar to that of e-PlanCheck in Singapore; however, DesignCheck has the advantage of supporting the ability to check for compliance at various stages in the design process, as it has a rule schema for early and detailed design stages as well as for specification. It is therefore targeted at Architects and Designers rather than just Building Control certifiers [13]. As yet, DesignCheck does not have the ability to view 3D models and all reports are text based.

3.4. The United States (General Services Administration and International Code Council)

Similar work on code-checking began in the United States (US) around 2000, with the initial emphasis on health, safety and welfare. Whilst several major projects have been carried out by the General Services Administration (GSA) in this area [20,21], perhaps the most interesting initiative (due to the accessibility of rule creation to non-programmers) is the aptly named SmartCodes – a project driven by the International Code Council (ICC), in conjunction with AEC3 and Digital Alchemy. The SmartCodes project has focused largely on addressing the problem of transforming paper-based codes (of which there are thousands) into machine-interpretable rules; generally a lengthy process requiring much iteration between building code officials and software developers. In order to streamline this process the SmartCodes project developed a methodology for "marking up" electronic copies of building codes using a 'tag dictionary', or ontology [22]. A customised XML editor supported by the SmartCodes schema allows the building code officials, to highlight objects, their properties and their constraints. A dictionary of properties supports the user to help ensure consistency of terminology. The rules are then automatically extracted, following a strict mathematical pattern, to form a "requirements model". This is then captured as a series of ordered constraints and encoded according to the IFC constraints model [23]. The rules can currently be executed using either Solibri Model Checker, or AEC3 XABIO. The SmartCodes project does not support any building code-specific information that is not currently implemented by BIM vendors [6].

Several of the initiatives outlined above have focussed on creating rules and mapping the entities encapsulated within them to the international building model schema. This schema is designed to support the needs of an international user and takes little consideration of different national terminology and semantics. The result is that the authors of the regulations will be required to accept mappings between the concepts in practice and their abstract counterparts in the IFC schema. For example a water closet (WC) is a well-understood description in England and Wales but in the IFC schema would be represented as two separate 'sanitary terminals', one to represent the toilet pan, and the other to represent the cistern. Rules derived from the regulations

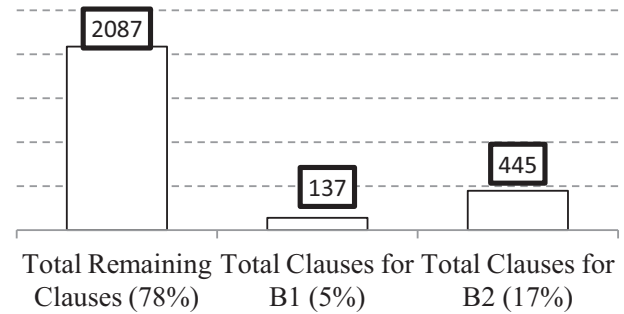


Fig. 1. England and Wales Fire Safety Regulations: Total B1 and B2 clauses as part of the total number of clauses.

that are mapped to this IFC schema will be difficult for the authors to understand and in the long term will make maintaining the rule base complex.

Similar to the FORNAX approach, our work will develop a building model schema embodying concepts in custom and practice specific to England and Wales; mappings will be created between the schema and the IFC schema through the domain extension approach, ensuring interoperability and maintainability. It is believed that this mapping will have long term durability. Authors will subsequently define rules in terms of the schema ensuring comprehensibility and maintainability. Since work on the FORNAX system began there have been significant developments in the IFC schema with the release of IFC 2x3 in January 2011, as well as computing languages that can implement it. These developments make it timely to revisit the FORNAX approach where each object contains all the relevant attributes for the codes as well as the rules that apply to that object.

4. The building regulations of England and Wales – suitability

In the context of England and Wales, it is important to have building regulations that are able to respond to the opportunities provided by these technical developments. However, there are characteristics of these regulations that make this transition difficult, as examined below.

4.1. Subjectively complex in nature

It is important to acknowledge that building regulations are complex and at times subjective in nature and therefore building regulation experts need to be involved in their conversion to computer interpretable rules to ensure the correct interpretations for the code checking. Software developers should not be expected to deal with the prediction of meaning from building regulations without a framework in place to allow domain experts to check on whether their understanding is

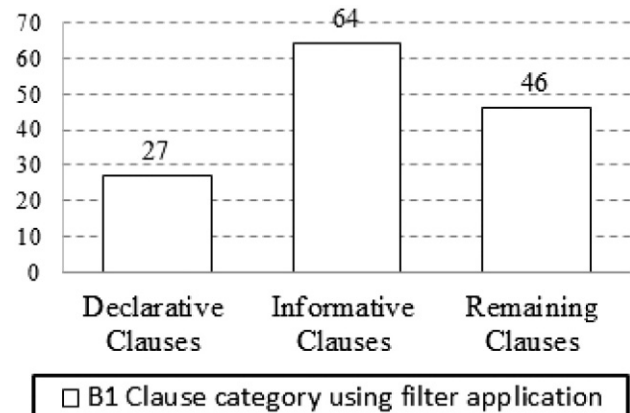


Fig. 2. Sorting of clauses into different categories.



Fig. 3. Entities extracted from the UK Part B1, B2.

correct or not. Such a framework would help to eliminate concern over loss of integrity of intent [4]. An example demonstrating the need for domain expert input is given below, extracted from Clause 2.8b of Part B1 of the UK Building Regulations Approved Documents [24], which refers to emergency egress windows.

The window or door should enable the person escaping to reach a place free from danger from fire.

It is apparent that there is potential for varying interpretations in this instance, particularly with reference to “free from danger from fire”. This could lead to errors during the extraction of the rules if not completed by a domain expert.

4.2. Inconsistent use of terminologies

A review of the existing building regulations for England and Wales by the authors suggests that entities or objectified concepts are terminologically inconsistent both within an Approved Document and across Approved Documents. Hence, knowledge formalisation becomes vital to ensure consistent terminology throughout all the sections of the building regulations rendering the process of automation to be efficient and robust.

An example demonstrating the inconsistent use of terminologies is provided below using Section-1; fire detection and fire alarm system of Part B1 of the Building Regulations. Entities referred to in the Section-1 clauses, include alarm, units, smoke alarm, detector, smoke detector, heat alarm, detection equipment, alarm receiving centre, heat detector, wall mounted unit and ceiling mounted unit. All of the above are used inconsistently, sometimes within the same clause, and all refer to the same general concept, but it is unclear what differentiates them.

4.3. Complexity of their structuring and inter-relationships

The England and Wales Building Regulations are composed of 14 different parts that are updated frequently and individually for reasons such as changes in the law, consultation processes, and extraordinary events [25]. Part L, which deals with the Conservation of Fuel and

Power, for example, has been significantly updated every year for the last 4 years, whilst Part F dealing with Ventilation has only been updated once during the last 4 years. Since the 14 parts represent different specialised domains, they each are updated asynchronously by respective subject specialists, even though, as in the previous 2 examples, there may be significant correlation between the 2 domains. This has resulted in a situation where, from a code compliance point of view, continuity and consistency across the regulations are sometimes missing. Because of this need to be responsive, the maintenance of an automated rule base needs to be kept separate from, and independent of, any proprietary software updates and formats.

5. An object-oriented approach

Building regulations are created and managed by people. They are represented in human linguistic formats, typically in the form of lengthy subjective text, numerical tables and sometimes in equations [26]. As more and more consultants are producing semantically rich, object-oriented building models the need for a shift in authoring practice, bringing consistently defined building objects with associated properties to the forefront, becomes apparent [11]. If the England and Wales Building Regulation clauses are object-centric, with consistently defined properties, it will be easier for architects to reflect that information in their building models.

In this context, the Royal Institution of British Architects Enterprises has made progress by creating an elemental view of the Building Regulations [25]. This elemental view helps in understanding the impact of clauses on individual building objects and is maintained via a complex matrix showing building objects and their relationship to building regulation clauses and the classification system UNICLASS. Knowledge formalisation such as the above provides suitable, significant and required data for the development of the Building Regulation-specific object modelling.

5.1. Knowledge formalisation

The basic aim of knowledge formalisation in the context of automated compliance checking is to interpret a body of building regulation knowledge and convert it into a set of rules that can be processed by a computer application [4]. The formalisation of building regulations in this context can be achieved by the following three steps:

1. Selecting an appropriate building regulation sample belonging to a specific building-related aspect.
2. Classifying building regulation clauses into those which are computer-interpretable (declarative) and those which are not (informative).
3. Decomposition of the declarative and informative clauses to extract semantics.

Table 1

Categorisation and clause numbers relating to the knowledge formalisation process.

Clause semantic filter level	Clause semantic filter brief	B-Reg	Clause numbers
First semantic filter	Computer interpretable, information obvious as checkable/can influence project parameters, simple geometrical rules which when applied to an element can return true or false	Part-B1	1.1,1.3,1.4,1.5,1.6,1.8,1.10,1.11,1.12,1.13,1.14,1.15,1.16,1.17, 1.18, 1.20, 2.8, 2.14, 5.3, 5.4, 5.7, 5.8, 5.14, 6.1,6.7,7.4,11.2
Second semantic filter	Information is not obvious as checkable, needs human interpretation to understand the exact content and meaning, codes/regulation involves natural language	Part-B1	1.2, 1.7,1.9, 1.19, 1.21, 2.1,2.2,2.3,2.4,2.5,2.9,2.10,2.11,2.12, 2.13, 2.16,2.17,2.18,2.19, 2.20, 3.1, 3.2,3.5,3.8, 3.9, 3.10, 3.12, 3.14, 4.5, 4.6, 4.7, 4.8, 5.1, 5.2, 5.5, 5.6, 5.9, 5.11, 5.13, 6.5,6.6, 7.2,7.3,7.6,7.7,7.8,7.9, 7.11, 7.12, 8.1,9.1,9.2,9.3,9.4,9.7,9.10,9.13,9.15,9.16,9.17, 11.1,11.3,11.4,11.5
Remaining clauses not suitable for compliance checking	Clauses which are not suitable for automated compliance checking	Part-B1	1.22, 1.23, 1.24, 2.6, 2.7, 2.15, 3.3, 3.4, 3.6, 3.7,3.11, 3.13,4.1, 4.2, 4.3, 4.4,5.10, 5.12, 6.2, 6.3, 6.4, 6.8, 7.1, 7.5, 7.13, 7.10, 7.13, 7.14, 8.2, 8.3, 8.4, 9.5, 9.6, 9.7, 9.8, 9.9, 9.11, 9.12, 9.14, 10.1,10.2,10.3, 10.4, 10.5,10.6, 10.7, 10.8, 10.9

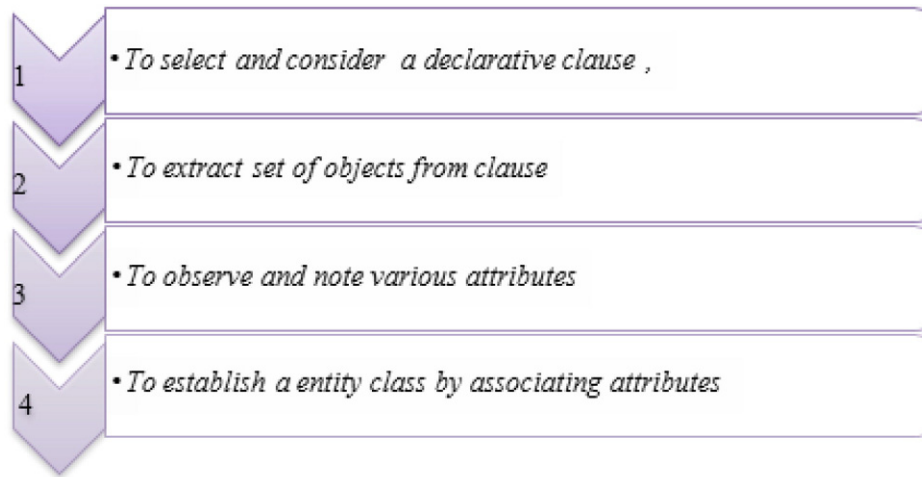


Fig. 4. Flow chart showing the development of an object class.

5.2. Execution of knowledge formalisation

The England and Wales Fire Safety Regulation Part B1 was selected as a sample for this research. Part B1 was chosen as it had been updated recently, was well-documented and involved clauses that are used regularly in practice. It has eleven different sub-sections, comprising 137 clauses. Knowledge formalisation began with Section-1, which has 24 clauses. Fig. 1 illustrates the numerical and percentage make-up of Parts B1 and B2 compared with total clauses in the document.

A filter system was then used, to determine whether the regulations are easily computer interpretable or not [6]. Constraint based assertions (i.e. those rules that, when applied to an element, will return either true

or false) were first filtered from the system and the resulting sub-set of clauses referred to as declarative clauses. Using this first filter, 27 declarative clauses were filtered out (Fig. 2).

Examples of declarative clauses:

Smoke alarm should not be fixed next to or directly above heaters or air conditioning outlets.

There should be at least one smoke alarm on every storey of a dwelling house.

The next filter extracted clauses which have been termed 'informative clauses' as they possess subjective information relating to building regulations. They do not deliver as direct a meaning as the declarative clauses and contain data only partially suitable for interpretation into

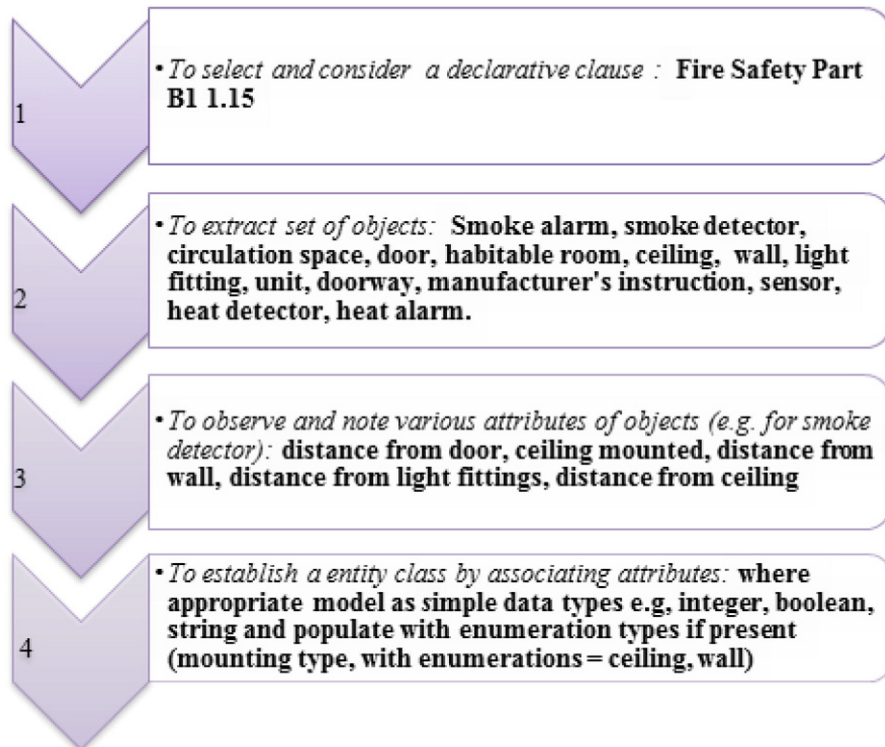


Fig. 5. Development of an object class from Fire Safety Part B1 1.15.

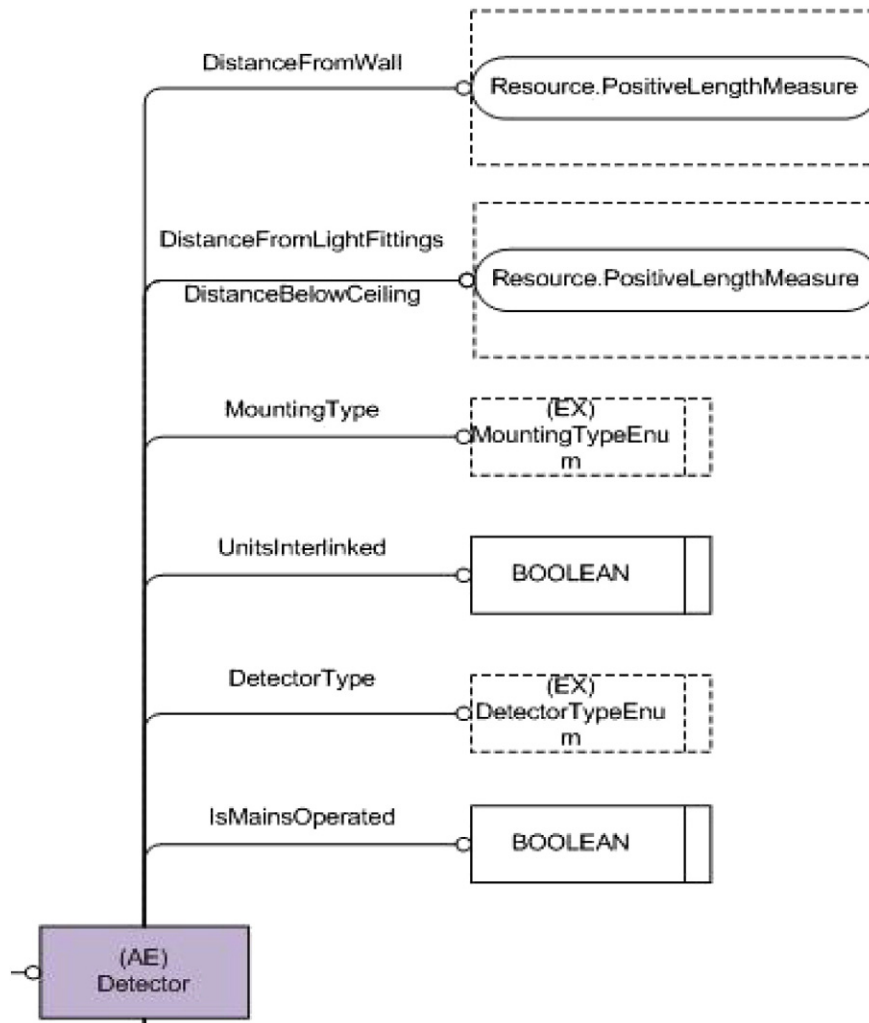


Fig. 6. Object class 'Smoke Detector' represented in Express-G.

computer rules that can be processed. Fire Regulation Part B1 features 64 such informative clauses (Fig. 3).

Examples of informative clauses:

- There should be routes of sufficient number and capacity.
- There should be appropriate means of escape in case of fire from the building.

By applying filters one and two, 27 + 64 clauses were extracted. The remaining 46 clauses were considered unsuitable for automated compliance checking. The categorisation of Part B1 clauses shown above, is further elaborated in Table 1.

5.3. Extracting semantics from the B1 building regulations

Once the declarative and informative clauses had been filtered, the physical entities juxtaposed with their attributes (or properties) were extracted. The resulting semantics, showing objects contained within the sample and their relationship to associated properties was used to inform an elemental view of the UK fire safety clauses as part of the knowledge formalisation process. Fig. 3 illustrates that from the total 137 clauses that were targeted in Part B1, 122 entities were extracted. The above methodology was repeated for fire safety Part B2 resulting in 228 entities extracted from 445 clauses (Fig. 3).

The above extracted entities formed the basis for the development of an IFC compliant Building Regulation-specific data model.

5.4. Building Regulation-specific model schema

The entities, once extracted were used as the basis for creating an object-oriented representation of Part B of the Building Regulations. Initially, this "data model" was created by specifying object classes for each entity and defining each attribute associated with that entity. Attributes were extracted using the same method as above, i.e. on a clause-by-clause basis, so that each object class developed to give a semantically rich object based view of the Building Regulations. This methodology is illustrated in Fig. 4.

In order to demonstrate this methodology, Clause number 1.15 from B1 [26] is considered for modelling, as it is of the 'declarative type' shown in Table 1, above. Clause 1.15 relates to the positioning of smoke alarms/detectors and is shown below.

Clause 1.15 Smoke alarms/detectors should be sited so that:

- a) There is a *smoke alarm* in the *circulation space* within 7.5 m of the *door* of every *habitable room*
- b) They are *ceiling mounted* and at least 300 mm from *walls* and *light fittings*. Units designed for *wall mounting* may also be used provided that the *units* are above the levels of *doorways* opening into the *space* and they are fixed in accordance with *manufacturer's instructions*
- c) The *sensor* in *ceiling-mounted* devices is between 25 mm and 600 mm below the ceiling (25–150 mm in the case of *heat detectors* or *heat alarms*).

Fig. 5 details the entities extracted from clause B1–1.15, including smoke alarm, circulation space, door, habitable room, wall, light fittings, and doorway. Once the entities had been extracted, the attribute types were observed and noted from the clause.

These attributes were then associated with their respective extracted entities and the model enhanced by establishing relationships between the object and entities including establishing hierarchical structure. The hierarchical structure was particularly useful for rationalising some of the terminological ambiguities previously mentioned, for example the relationship between smoke alarms, smoke detectors, heat alarms, and detection equipment. Fig. 6 illustrates the object class: 'Smoke Detector'.

The use of enumerations for many of the attributes (for example, the different mounting types for a detector, as shown above) extracted from the building regulations, was also very significant for formalising the UK fire safety building regulations context, allowing the model to represent allowable values for non-habitable spaces. A number of broad stages can therefore be identified for rule authoring. These are: object identification; defining attributes and enumeration; establishing semantic relationships and object transformation into classes.

6. Conclusions

Whilst other open standards exist for building models (for example gbXML), the IFC standard has the most comprehensive coverage. Without the use of an interoperable open standard format, compliance checking rules would need to be modelled and maintained separately for each proprietary BIM software package. This is not only inefficient and unsustainable, but could lead to inconsistency of results. Previous initiatives in countries such as Australia, Singapore, Sweden and US have already used the IFC standard for rule checking.

The analysis of two parts, B1 and B2, of the England and Wales Building Regulations identified over 350 semantic entities. By inspection it is clear that many of these, for example the space model, will have relevance to other parts of the regulations. However, it is clear that creating formalisations of regulatory information will generate many more detailed entity definitions than are currently in the IFC schema. A significant number of these definitions are, in reality, refinements of IFC definitions. For example "Habitable Space" is a refinement of "IfcSpace". These refinements can be modelled using Ifc decorator classes such as IfcClassification, IfcRelationships or the extensible IfcPropertySet mechanism. The terminology that is required to populate this information is reasonably well defined in the regulations and for the most part consistent across the standards. The use of enumerated values based on this terminology and specific to the UK (or any localisation) context could provide a simple and effective mechanism to formalise and localise Building Information Models for compliance checking.

Problems associated with automated compliance with building regulations have been examined. Many of these can be overcome through knowledge formalisation. Whilst it may not be currently feasible to write computer interpretable rules for compliance with all building regulations, nevertheless, much of their coverage is suitable for automated checking. For example, a specific focus on automating the process for the declarative clauses in Part B could have significant benefits for the industry, including:

- shortened building regulation application process;
- ability for consultants to pre-check applications for completeness of information as well as compliance, at any stage in a project; and
- a consistency check for Building Regulation authors.

It is suggested that knowledge formalisation is essential before one can start the development of the Building Regulation-specific object model. Whilst BIM is becoming popular, it is not common for the models to contain semantically rich information. An object-based representation of building regulations could define the minimum amount of data

required in order to be able to test for compliance and in so doing help add value to semantically rich models.

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