Digitally Enabled Asset Life-cycle Management

Final Industry Report
Project 2.82

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Executive Summary

It is evident that digital models, including Building Information Modelling (BIM) models, should be maintained after construction, and changes and updates should be appropriately recorded and updated. This process should be disciplined and standardised. BIM models developed at the design stage can be extended for use in the operational and maintenance stages. At these stages, a study of BIM helping to capture asset information for effective asset management decisions is extremely important.

Recently, there has been a strong requirement in the industry for 3D models to be connected to real sensors to reflect real asset conditions. Such models will survive because the shapes and colours change as the asset conditions change, enabling quick responses to potential problems of the built assets and helping to transform maintenance activities from reactive to predictive.

To achieve this objective, a key problem is to update Digital Engineering (DE)/BIM models based on real asset conditions that can be collected using innovative technologies, such as sensors or high-resolution cameras. The translation of raw data, such as images, into useable asset condition data is the key to achieving asset life-cycle management.

The ultimate goal of the industry is to streamline and standardise these processes to realise value and efficiency.

The specific objectives of the case studies included in this industry report are:

1. To demonstrate the value of BIM, particularly for small-scale projects. While there are many recent reports on BIM value, these reports should be critically analysed and BIM value for specific types of projects, including small-scale projects, underground assets and heritage assets, should be highlighted.
2. Developing a DE-enabled asset life-cycle management process and prototype to ensure that DE/BIM models remain alive after construction and handover. The prototype should have the capacity to reflect real asset conditions to enable effective and rapid operation and maintenance decisions.
3. To use latest technologies, such as image processing, to collect real-time asset conditions and investigate an approach to translate the raw data collected from these latest technologies into useful asset data that can be integrated and reflected in the prototype.

The outputs can be implemented in assisting the integration of innovative technologies and approaches, including BIM and machine learning, for the effective life-cycle management of building, housing and infrastructure projects.

Introduction

Construction projects are complex and require effective coordination and management to ensure their successful completion. Four-dimensional (4D) construction simulations have become popular as a tool to improve project coordination and efficiency. This report focuses on Industry Foundation Classes (IFC)-based 4D construction simulation and its benefits compared to proprietary 4D software such as Navisworks and Sychro4d. IFC is an open-standard data model widely used in the building and construction industries.

By utilising IFC, 4D simulations are made more interoperable and flexible than proprietary 4D software. This report provides an overview of IFC, its benefits and the key steps involved in developing an IFC-based 4D simulation using MetaBIM (https://metabim.com.au/), a web-based OpenBIM platform for Building Information Modelling (BIM) data parsing, editing, checking, auditing and visualisation.

BIM and IFC

BIM is a digital representation of the physical and functional characteristics of a building or an infrastructure project. It uses 3D models, data and information to support decision-making throughout the life cycle of a building. BIM has enabled improved collaboration, cost savings and increased efficiency in the construction industry.

IFC is a data model used to store and share information about a building or infrastructure project. It is based on the concept of objects, which are entities that represent physical or functional aspects of the building such as walls, doors or electrical systems.

Each object has properties such as dimensions or materials and relationships such as spatial or logical connections that can be used to describe the building in detail.

The IFC format is platform independent and can be used to exchange building information models between different software programs and systems. This allows better collaboration and coordination among different stakeholders, such as architects, engineers and contractors, and enables them to use their preferred software to work on the same project.

IFC-based 4D Construction Simulation: Benefits

Commercial 4D software such as Navisworks and Sychro4d are specialised tools that assist with construction scheduling and coordination. They allow users to generate 4D simulations of construction projects by integrating 3D models, schedules and quantities. These software programs can import IFC models; however, they do not support all the properties of the IFC standard, particularly those related to construction scheduling such as *IfcTask, IfcWorkSchedule, IfcConstructionResource, IfcWorkCalendar* and the like. Furthermore, using proprietary software to save a 4D simulation results in major limitations, as editing or viewing the simulation using other software programs becomes difficult.

The use of IFC for creating and saving 4D construction simulations provides several benefits, particularly in the areas of longevity and interoperability.

Longevity refers to the ability of the 4D simulation to be used and accessed over a prolonged period of time, even if the software or company that created it becomes obsolete. IFC is an open, ISO-standardised data format, not tied to any specific software program or vendor.

This allows the 4D simulation to be read and used by other software programs that support IFC and ensures the longevity of the 4D simulation and its future applicability.

Interoperability is the ability of different software programs and systems to operate seamlessly. The use of IFC in 4D construction simulations allows for interoperability. Therefore, different stakeholders in a construction project, such as architects, engineers and contractors, can use different software programs but can still exchange information seamlessly. This improves collaboration and coordination between stakeholders and reduces the risk of errors and delays caused by data incompatibility.

The latest version of IFC is IFC4.3, which was released in 2018. It provides new features and improves the information model to support more sophisticated use cases such as construction simulation, energy performance and building operation. IFC is becoming an important standard in the construction industry and many software vendors and building owners are actively participating in its development and implementation.

IFC-based 4D Construction Simulation: A Pilot Study

The main objective of this pilot study is to demonstrate the development of an IFC-based 4D simulation for construction scheduling on the MetaBIM platform developed in this SBEnrc project. The project team used a sample BIM structural model provided by Autodesk (Figure 1). The model included detailed information on the geometry, materials and systems of the building. The team also created a construction schedule using Microsoft Project.

The development process can be divided into the following key steps:

1. Import the IFC file: The first step is to import the IFC file of the sample Structural BIM model into MetaBIM. The IFC file contains the 3D model of the building as well as information about the different components and their properties.
2. Import the external schedule in CSV format: Next, an external schedule from Microsoft Project in CSV format is imported into MetaBIM. This schedule contains information on the tasks, resources, starting dates, finishing dates and duration of the construction project.
3. Edit work schedule attributes: The imported schedule is edited to match the attributes of the IFC model such as task names and resource assignments. This step is necessary to ensure that the schedule and model are properly aligned.
4. IFC search and mapping: Once the schedule has been edited, MetaBIM conducts an IFC search to identify and map relevant objects in the IFC model to tasks in the schedule. This step links the schedule and model, allowing the simulation to be run.
5. Auto-assignment of IFC objects to tasks: The software automatically assigns IFC objects to the appropriate tasks, ensuring accurate and consistent simulation.
6. Create and run a construction simulation: Finally, run the simulation and visualise the results in the form of a 4D construction simulation (as shown in Figure 2). This simulation analyses the construction schedule and identifies potential issues or conflicts, thus improving the overall efficiency and coordination of the project.
7. Export 4D simulation to IFC: The 4D simulation can be exported to the IFC format, which can be re-imported or edited by other 4D software programs, such as BlenderBIM (https://blenderbim.org).

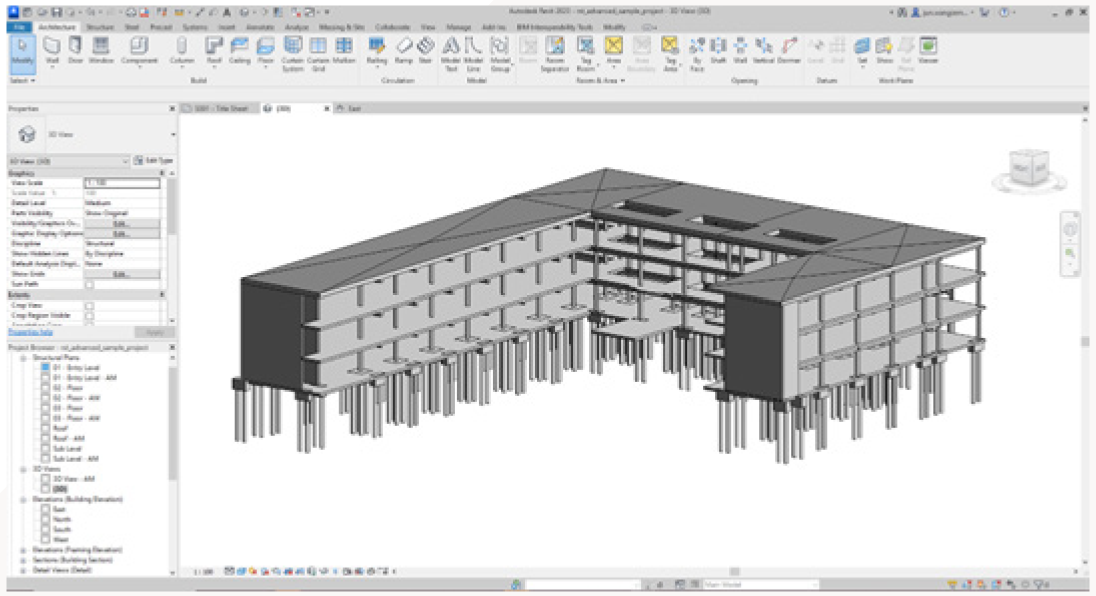


Figure 1. Autodesk Revit Structural Sample Model

1.0 Industry Foundation Classes (IFC)-based 4D Construction Simulation (cont'd)

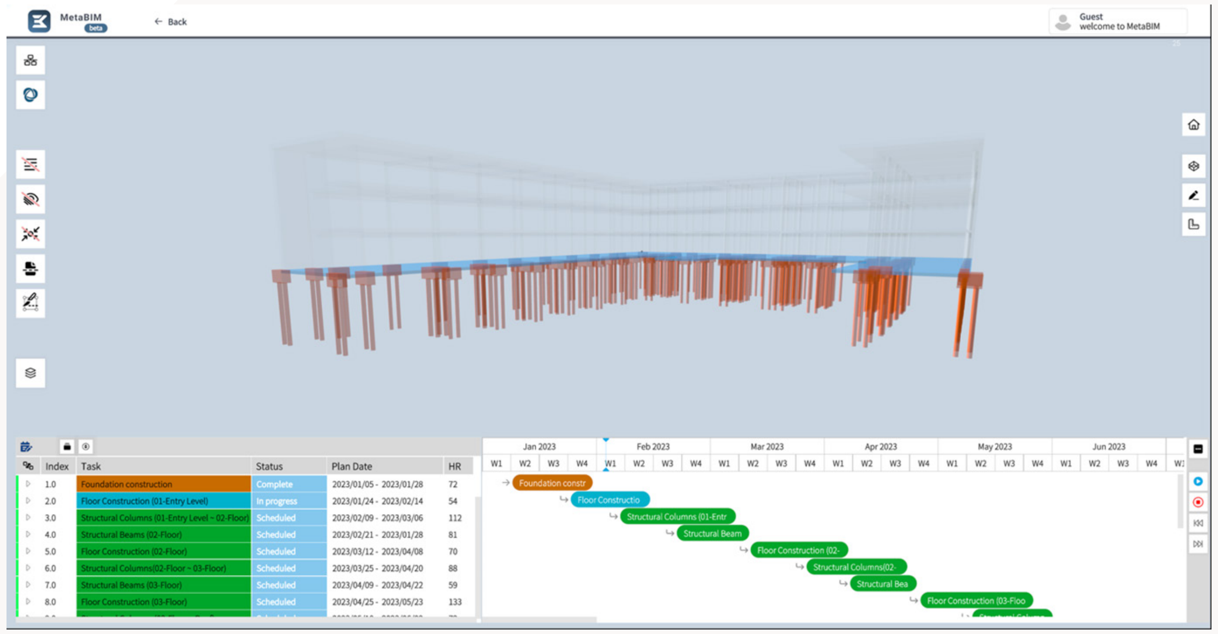


Figure 2. IFC-based 4D Construction Simulation through MetaBIM Platform

Concluding Remarks and Recommendations

In conclusion, the IFC-based 4D construction simulation is a powerful tool for improving the coordination and efficiency of construction projects, offering several advantages over proprietary 4D software such as Navisworks and Sychro4d.

Among the main benefits of using IFC is its longevity and interoperability, which allow 4D simulations to be easily shared and edited by various software programs. This is in contrast to proprietary 4D software, which saves simulations in a proprietary format that are difficult to edit or view using other software programs.

In addition, IFC supports a wide range of construction schedule-related entities or classes including *IfcTask*, *IfcWorkSchedule*, *IfcConstructionResource* and *IfcWorkCalenndar*, which are not supported by proprietary software.

To develop an IFC-based 4D simulation, the key steps include importing an IFC file, importing an external schedule in CSV format, editing the work schedule attributes, IFC search and mapping, auto-assigning IFC objects to tasks and creating a construction simulation. When executed correctly, these steps enable an accurate and efficient 4D simulation that can significantly improve the coordination and overall success of a construction project. Therefore, the IFC-based 4D construction simulation is a valuable addition to the BIM workflow.

2.0 Roadside Wall Detection Using an Artificial Intelligence and Computer Vision Approach

Background

Roadside walls are common highway structures. These offer functions such as noise reduction. To ensure quality, these wall structures should satisfy general physical and specific acoustic requirements. In terms of physical requirements, the appearance of roadside wall structures, including height, colour and materials, should be acceptable to the local community and government authorities. Wall designs should be consistent. Durable materials should be used. In Western Australia (WA), roadside walls should have a minimum design life of 50 years (Main Roads WA 2020; Main Roads WA 2022).

Once the construction is completed, wall structures must be appropriately maintained and managed. Currently, the condition of roadside wall structures is monitored manually by surveyors through inspection. However, manual inspection is expensive, time-consuming and has limited accuracy. Developing an automatic object detection tool for roadside wall objects can help address these challenges.

Therefore, this case study aims to use an artificial intelligence (AI) approach in detecting key types of roadside wall objects in WA.

Objectives

This case study aimed to develop a tool for extracting features and recognising objects in roadside wall structures. Limestone design, post and wall panel design, and post and wall panel with screen design are the three common roadside wall types, as shown in Figure 3. Other types will be considered in the next development phase.

The specific objectives are:

1. The proposed method should be able to automatically detect these three types of roadside walls along highways with acceptable accuracy.
2. The developed tool should be compatible with the current open-access programming environments to facilitate testing and further development.
3. Linking the detection results with other features such as the height and geolocation of roadside wall structures should be feasible.

(a) Limestone (b) Post and wall panel (c) Post and wall panel with screen

Figure 3. The Three Types of Roadside Wall Structures in the Case Study

2.0 Roadside Wall Detection Using an Artificial Intelligence and Computer Vision Approach (cont'd)

Method and Results

This project selects the 'You Only Look Once Version 5' (YOLO-v5) as the object detection algorithm considering the following benefits. First, YOLO-v5 is the latest convolutional neural network (CNN) machine-learning model with acceptable performance, which improves the accuracy of previous models. Second, the model was designed with minimal programming code, which is suitable for this pilot case study. Third, the programming is based on the 'Pytorch' environment, which is easier for further extension and adoption in the following phases (Al-Tameemi et al. 2023; Bie et al. 2023). The CNN object detection method comprises four stages of data processing: object feature extraction with labels; algorithm training; model performance evaluation; and inference (model test) for selected videos.

The raw inputs for the case study were 12 videos from the high-speed data provided by Main Roads WA, as shown in Figure 4. These 12 videos were observations of road construction along the Kwinana Freeway (Road-H015), Mitchell Freeway (Road-H016) and Tonkin Highway (Road-H017). Eight of the 12 videos were from the Kwinana Freeway. In total, 1,059 images were selected from the 12 videos. In this study, the training test/validation ratio was set as 9:1. Thus, 953 images were randomly selected as training datasets and the remaining 106 images were used for validation.

Figure 4. Observed Roadside Wall Structures from the Dataset

Roadside wall structures were extracted and highlighted using labels from the dataset. Among these image labels, 294 were limestone walls (approximately 28 per cent), 411 were post and wall panel designs (approximately 38 per cent), and the remaining 366 (approximately 34 per cent) were posts and wall panels with screen designs.

The performance of the trained YOLO model, as measured from the loss values and accuracy, is shown in Figure 5. In this case study, a pilot test comprising 50 training sessions was conducted. In terms of accuracy, the best-trained parameters occurred at the 35th training iteration.

This optimal set of parameters had a precision of 93 per cent and mean averaged precision (mAP) of 91 per cent. The optimal parameter set was chosen as the model for this pilot case study, and these parameters were used for further testing.

All three types of wall construction features mentioned above were effectively detected with high accuracy. The developed model is also capable of recognising complex wall features such as different types of side-by-side roadside walls. See Figure 6 for examples.

Figure 5. The Performance of the Developed Model

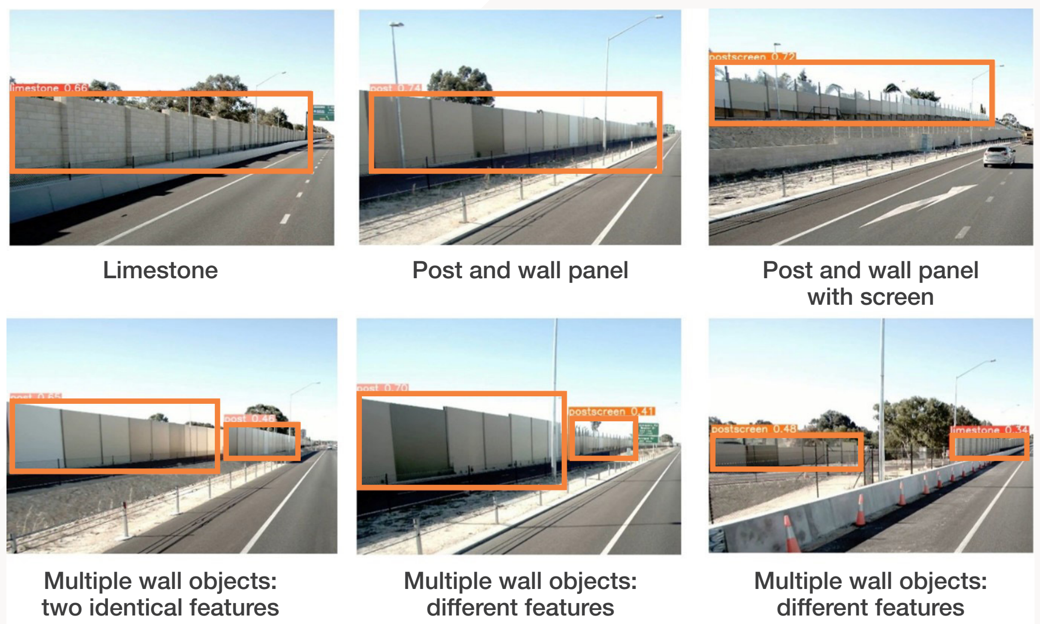


Figure 6. Detection of the Three Types of Roadside Wall Structures and Other Complex Structures

2.0 Roadside Wall Detection Using an Artificial Intelligence and Computer Vision Approach (cont'd)

Concluding Remarks and Recommendations

The general performance of this pilot machine learning model is acceptable; however, its accuracy is limited owing to misclassification and issues such as missing objects blocked by other features.

Misclassification error is related to wall features being correctly recognised but categorised as incorrect (see Figure 7 for examples). This predominantly occurs when detecting post and wall panels and post and wall panels with a screen, as they have similar exterior designs (at certain levels). The model is less accurate when the transparent screens (for post and wall panels with a screen) are small or far apart. This limitation can be overcome by further training, with a special focus on the two wall types.

Other issues are related to the wall types being blocked by other features, such as vehicles and road signs (see Figure 7). Some parts of roadside walls are inevitably blocked by plants, other man-made construction objects or moving vehicles. This can be addressed by developing an inference code to infer the wall type based on those detected in the preceding and subsequent frames.

Nevertheless, AI can be used for roadside wall detection with satisfactory performance, and extending its use to detect roadside walls for the entire network is feasible.

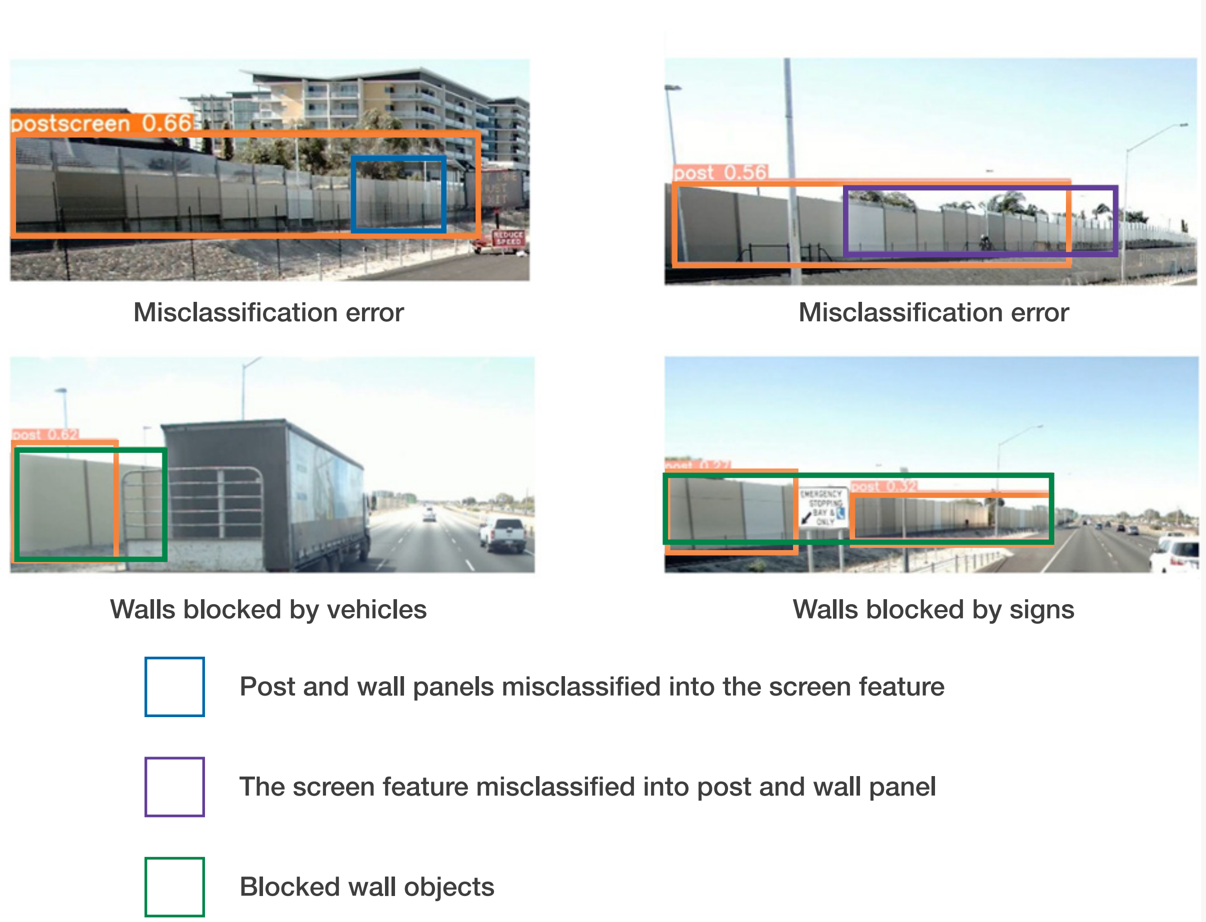


Figure 7. Example of Detection Errors in the Case Study

Background

Providing accessibility in housing for people with disability is important for their wellbeing and active participation in the community. Currently, social housing can be built at the Gold or Platinum level based on the *Livable Housing Design Guidelines.*

However, the categorisation of Gold or Platinum by the *Livable Housing Design Guidelines* may not meet the needs of individuals with disability from a healthcare professional's perspective. Therefore, the mismatches and gaps must be identified.

Objectives

There are two objectives of this case study:

1. To conduct a comprehensive literature review related to the requirements of people with disability from a healthcare professional's perspective and provide clear matching with the Gold/Platinum *Livable Housing Design Guidelines.*
2. To investigate whether the requirements of individuals with disability can be met by existing housing designs; for example, through rule-checking in BIM, using existing complex BIM models from open sources to demonstrate their feasibility.

(Source: Black_mts – Adobe Stock)

Livable Housing Design Guidelines

Two separate interviews were conducted with two registered occupational therapists regarding their comments and suggestions related to the *Livable Housing Design Guidelines* and how such guidelines can support the needs of people with disability.

While the two interviewees were positive about the *Livable Housing Design Guidelines*, some of the notable findings from the interviews include:

1. Smart homes

Smart homes or smart houses are defined as structures with automated systems developed to provide building users with advanced commands and control over the functions of the building. (Öztürk and Naimi 2017). Some key features include controlled lighting, temperature, security, multimedia and fall detection/prevention sensors, which can be monitored and provided through mobile devices or the internet (Özçandır and Can 2021).

Smart-home technologies can considerably assist in the mobility, accessibility and other key requirements of people with disability. However, this has not been reported in the *Livable Housing Design Guidelines.*

2. Interconnectivity

While the *Livable Housing Design Guidelines* provide detailed dimensional requirements for housing elements such as kitchen space, living room space and toilets, the interconnectivity among these different spaces should also be considered. For example, some people with disability may need to use toilets more frequently at night, and the distance between the bedroom and toilet is a critical issue in such cases. The interviewees mentioned that the circulation in the house – that is, movement through, around and between spaces – should also be highlighted.

3. Matching disabled persons to appropriate housing

Housing affordability is a critical issue, particularly for people with disability. Under such constraints, people with disability are often 'slotted' into available or vacant properties. However, there are many types of disability, including vision and cognitive impairment. The current *Livable Housing Design Guidelines* do not provide adequate specifications related to the needs of people with such disability. For example, when accommodating visually impaired residents, plenty of light should be provided, particularly in dark areas. In addition, furniture should be outside the pathways and grab bars should be in places where necessary.

4. Livable community

The *Livable Housing Design Guidelines* provide specifications for the physical accommodation environment. However, connections to the community are also important for the emotional wellbeing of people with disability residing in livable houses. Some design examples include comfortable outdoor settings and shared areas. In addition, the connection to the natural environment is not covered in the *Livable Housing Design Guidelines*, as natural environment can influence a person's wellness (McSweeney et al. 2015). Individuals who spend more time indoors may experience loss of vitality and health (Maller et al. 2005). Well-maintained and appropriate vegetation is considered a good strategy for improving the wellness of individuals.

5. Future-proofing livable houses

Currently, the *Livable Housing Design Guidelines* have a three-tier certification system but no mandatory standards. Mandatory standards were included in the minimum accessibility standards of the National Construction Code. However, gaps exist between meeting these standards and providing functional designs for people with disability. The minimum standards may not be sufficient for the remaining 10 per cent with higher requirements. With the expected growth in people living with mobility issues, future-proofing the current *Livable Housing Design Guidelines* is considered important. This may include incorporating accessible design features as mandatory in the guidelines, including the latest smart-home technologies.

3.0 Accessible Housing for People with Disability (cont'd)

BIM-based Livable House Design Check – A Pilot Study

The BIM-based Livable House Design Check refers to the utilisation of BIM to confirm that the proposed house design conforms to the *Livable Housing Design Guidelines*. In this pilot study, the design standard of Livable Housing Design Standard 2022 (LHDS), developed by the Australian Building Codes Board, was used as the compliance benchmark, and MetaBIM was used as the BIM-based checking platform.

The initial step in performing a BIM-based Livable House Design Check was thoroughly reviewing and interpreting the LHDS requirements and converting them into computer-readable formats. This included the creation of rules for clearance, circulation, lighting and accessible amenities.

Certain rules are easy to implement; for example, '*All internal doorways must have a minimum clear opening width of 820mm to allow for easy passage of wheelchairs and other mobility aids; and a clear minimum circulation space of 1200mm by 900mm must be provided from the front edge of the toilet pan*'. However, other aspects of the standard guidelines may be ambiguous, making it challenging to accurately apply the rules; for example, '*A continuous path to a dwelling entrance door must be provided from the pedestrian entry at the allotment boundary from the ground level of the adjoining land; or a car parking space within the allotment that is provided for the exclusive use of the occupants of the dwelling*'.

The next step was to create a detailed BIM model of the proposed house design using software such as Autodesk Revit. The model should include all essential building elements such as dwelling access, entrances, doors, walls, plumbing fixtures and shower facilities. The project team purchased a pre-existing model from the BIM Guru website (https://courses.bimguru.education/), as shown in Figure 8. When the BIM was complete, the design was evaluated for compliance with the rules developed in the previous step.

This was achieved using a series of checks and workflows defined within the MetaBIM software. Figure 9 shows the compliance check results displayed in a clear and concise manner, highlighting all non-compliant elements within the design. The results also include information specifying which rule was violated and the location of non-compliance elements within the model. This enables designers to quickly identify and rectify any issues before the construction begins. As Figure 9 shows, the dwelling entrance check has failed, as the width of the door leaf for the entrance door in the given BIM model is 820mm, which is less than the required 870mm for a clear opening width of 820mm for a single swinging door.

Finally, the results of compliance checking were documented and reported, and can be exported in a variety of formats such as PDF, Excel or Word. This includes creating a report that lists all non-compliances and provides detailed information about violated rules. The report can also be shared with relevant stakeholders such as building owners, architects or building inspectors.

The identified non-compliances can be rectified within the original 3D BIM authoring tool (e.g. Autodesk Revit), and the design is re-checked to ensure that it now complies with the *Livable Housing Design Guidelines*. This iterative process enables efficient resolution of any issues and delivery of a compliant design.

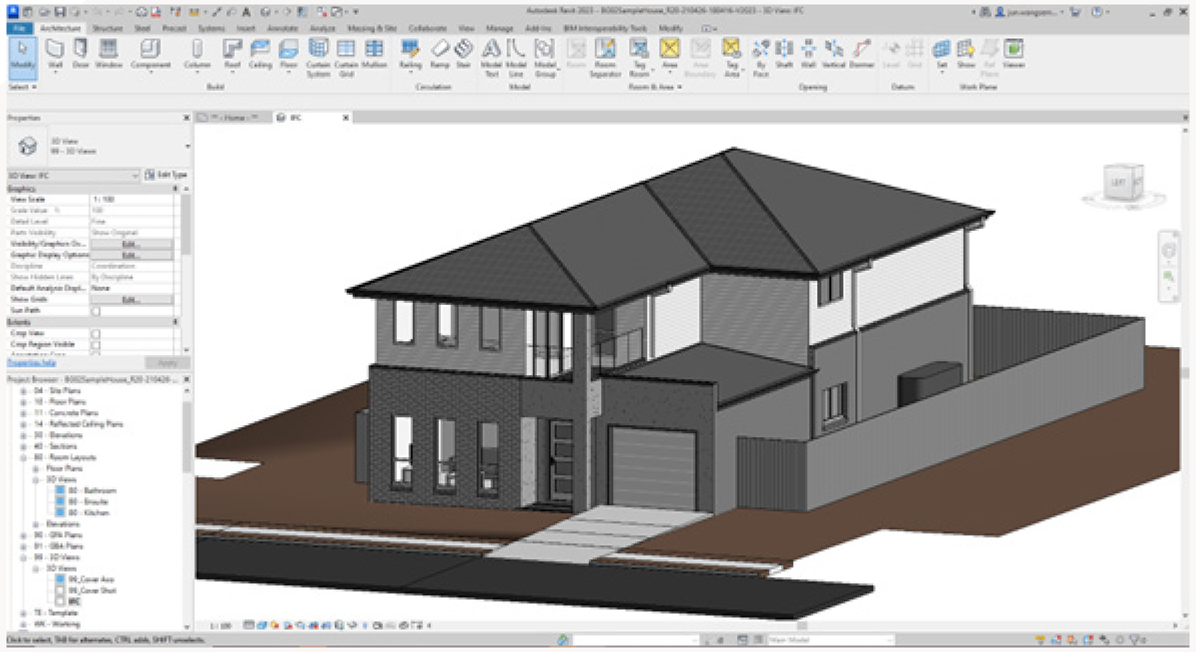


Figure 8. Revit House Model from BIM Guru

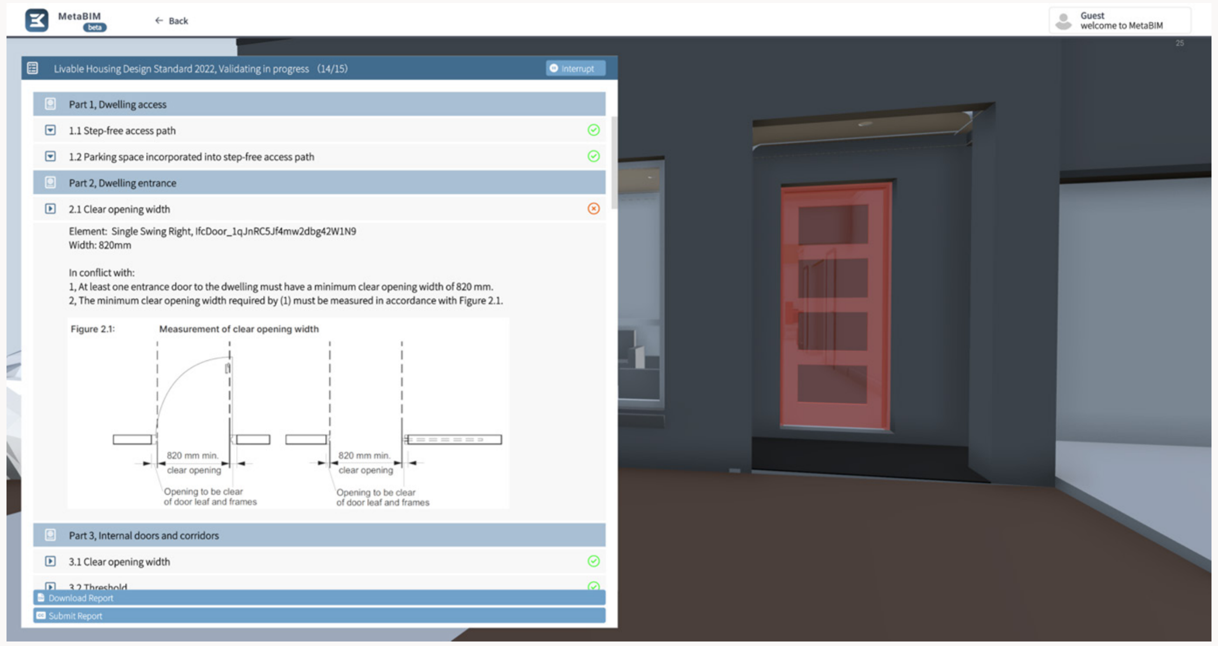


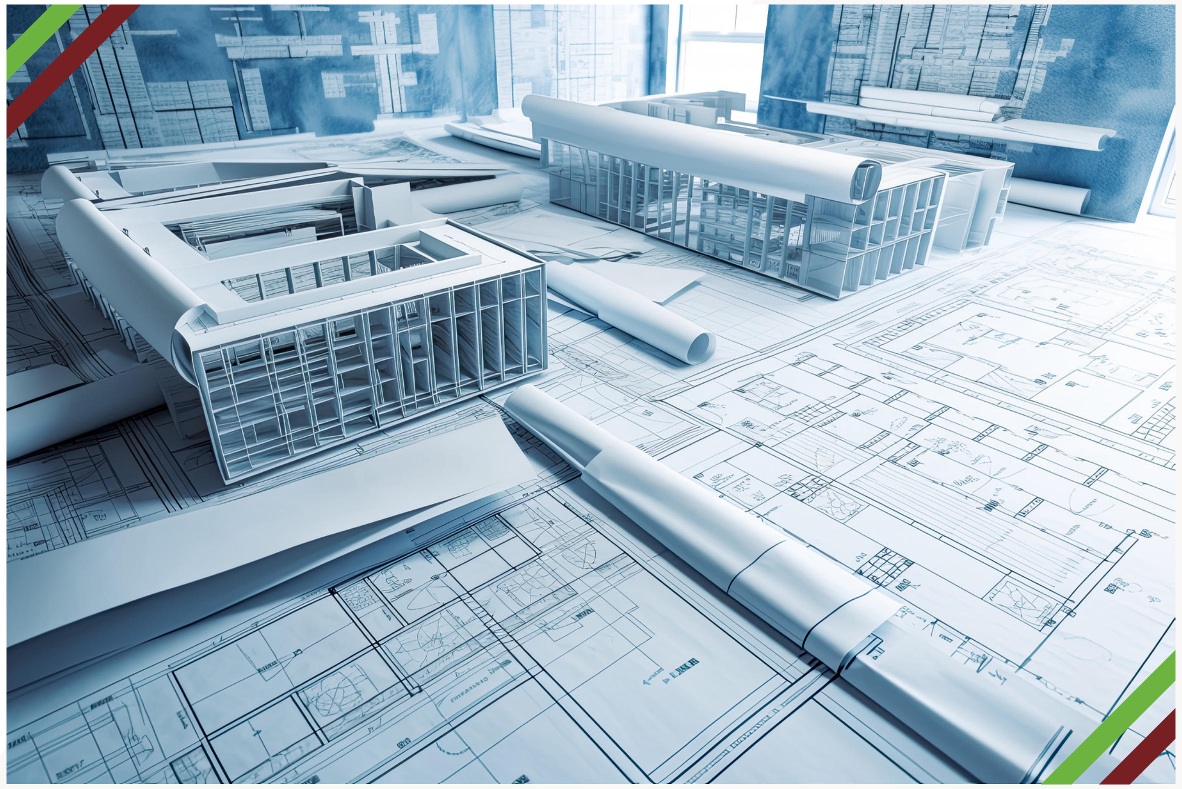
Figure 9. BIM-based Livable House Design Check

Concluding Remarks and Recommendations

Conducting a BIM-based compliance check for the LHDS requires a thorough understanding of the standards and BIM model preparation. The following are the important lessons learned from this pilot study:

1. Detailed understanding of the standard: A detailed understanding of the LHDS is required to accurately identify compliance issues.
2. Being abreast of new developments: Standards may change over time, and being aware of new developments, rules and regulations is important.
3. Consistency and accuracy in the application of rules: Ensuring rules are applied correctly and consistently to achieve the goals of the LHDS is important.
4. Accurate BIM model preparation: A BIM must be prepared with a high level of detail and accuracy to identify potential problems or non-compliance issues. Incorrect preparation of the BIM model can lead to errors and omissions, and in turn identifying compliance issues may become difficult.

In conclusion, the BIM-based Livable House Design Check is a powerful tool for verifying the compliance of new house designs with livable design guidelines. Using BIM software such as Autodesk Revit and MetaBIM, designers can create a digital representation of their design and verify its compliance with the LHDS. This process involves developing computer-understandable rules from the LHDS, creating a BIM model of the house design and checking the design to ensure compliance with the rules. The compliance check results are then reported and any non-compliance can be rectified and rechecked. Using the BIM-based Livable House Design Check, designers can improve the livability of their designs and reduce the risk of non-compliance during the building approval process.



(Source: Saulo Collado – Adobe Stock)

Background

BIM is a powerful tool for managing and maintaining buildings and facilities. It allows for the creation of detailed digital models of buildings that can be used for documentation, simulation and visualisation. MetaBIM (https://metabim.com.au/) is a web-based OpenBIM platform for BIM data parsing, editing, checking, auditing and visualisation.

The AUS-SPEC TECHguide *Guide to the Building and Facility Maintenance Management System and Documentation* outlines the protocols for compiling documentation related to the maintenance of buildings and facilities.

This explains the philosophy behind the development of the AUS-SPEC maintenance system, which is based on the principles of quality, competition and scheduled maintenance. It also covers the implementation of competitive maintenance contracts using both the principal's own business units and that of private contractors.

This study examined the role of MetaBIM in supporting the implementation of the AUS-SPEC TECHguide. Specifically, three key tasks were identified in which MetaBIM can contribute and these include: the classification of as-built BIM models, integration of asset data from various data sources, and validation of as-constructed data during handover stages.

Task 1 – Validation of as-constructed data during handover stages

Validation of the as-constructed data during the handover stages is crucial for ensuring the quality and accuracy of the data used for building and facility maintenance. It verifies whether the data provided by the contractor or subcontractor matches the actual as-built conditions of the building or facility. The validation process can be time-consuming and error-prone when performed manually; however, with the use of MetaBIM, it is more efficient and accurate.

MetaBIM can make an automated comparison of the as-built BIM model with the as-constructed data provided by the contractor or subcontractor.

This comparison performed in real-time can identify any discrepancies and address them immediately. In addition, MetaBIM can facilitate the data validation process by providing an intuitive interface for the facility manager or planner to review and approve the as-constructed data. This eliminates the manual data entry work and reduces the risk of error. Using MetaBIM, the validation process can be made more efficient and accurate, ensuring that the data used for building and facility maintenance are of the highest quality.

Task 2 – Integration of asset data from various data sources

Effective maintenance requires a comprehensive inventory of all assets. The AUS-SPEC maintenance system data requirements are aligned with the International Infrastructure Management Manual (IIMM) standard. According to IIMM Section 4.2.6, the potential sources of data for asset maintenance, as outlined in Table 1, include spatial data, textual records, attribute records, physical assets and other sources. However, these data are often stored in disconnected systems, which limit the full potential of this information.

MetaBIM can help integrate asset maintenance data from various sources by utilising the as-built BIM model as a central reference point and linking other relevant asset data to the corresponding levels of BIM objects. For example, maintenance records can be linked to specific BIM objects that are just maintained. MetaBIM supports the visualisation of different data types, such as CAD drawings, spreadsheets, 3D models, 4D animations, PDF reports and images. Consolidated asset maintenance data can be used to generate reports, improve the planning of future work, and aid in the management of buildings and facilities. Furthermore, integrated asset data improve the accuracy of cost estimation on a building/facility basis and promote the efficient and effective management of the network.

Table 1. Data Sources

	Type	Source
Spatial Data (Location, Length, Size)	• Plans/maps • Digital mapping	• Aerial photography • Drawings • Microfilms
Textual Records	• Plans/maps	• Payment schedules/inspection sheets
Attribute Records	• Separate databases • Fault/failure records • Card systems	• Maintenance/renewal records • Field books
Actual Assets	• Full-scale models	• Asset inspections
Other Sources	• Photographs during construction • CCTV inspection of pipes • Existing/previous staff and contractors • Financial Asset registers • Publicly available datasets (e.g. regional council hazard portals) • Crowd-sourced datasets	• Technical records • Asset performance • Hydraulic models • Automated and high-speed data capture platforms • Apps

Task 3 – Classification of as-built BIM model objects according to AUS-SPEC activity specification and NATSPEC maintenance reference work sections

The list of AUS-SPEC activity specifications and related NATSPEC reference work sections (Table 2) can be transformed into a formal maintenance reference code system, which can be accessed and stored within the MetaBIM platform. When receiving the as-built BIM models, facility managers or planners can efficiently assign activity codes, maintenance component codes and maintenance reference work sections to the corresponding as-built BIM objects. The classified and enriched BIM can serve as valuable data sources for linking with other maintenance management forms, including:

- Instructions for using the Building and Facility Maintenance Plan proformas
- Defect notice
- Defects notice register
- Notice of non-conformance
- Non-conformance report
- Preventative action request
- Corrective action request
- Community complaint form
- Work order/Work variation form.

This linked information can be utilised to streamline the maintenance planning process as follows:

- Automatically generating simple, clear checklists
- Automatically creating maintenance work packages for contractors and/or subcontractors.

Table 2. List of AUS-SPEC Activity Specifications and Related NATSPEC Reference Work Sections

AUS-SPEC Activity Specification	Activity Code	Maintenance Competent Code	Relevant NATSPEC Maintenance Reference Work Sections
Structure			
1530 External works	E	TM	0184m Termite management
		AC	0272m Asphaltic concrete
		SB	0273m Sprayed bituminous surfacing
		CP	0274m Concrete pavement
		SM	0275m Paving – mortar and adhesive bed
		SS	0276m Paving – sand bed
		LM	0259m Landscape maintenance

Concluding Remarks and Recommendations

In conclusion, this study examined the role of MetaBIM in supporting the implementation of the AUS-SPEC TECH guide. Using MetaBIM, three typical tasks that could be improved were identified. These are the as-built BIM model classification, asset data integration from various data sources and validation of the as-constructed data.

The use of MetaBIM can help improve the accuracy and completeness of building and facility maintenance data which, in turn, can assist with the efficient and effective management of assets. This study highlights the potential of MetaBIM to support the implementation of the AUS-SPEC TECH guide in practice, and further research can be conducted to explore other potential benefits of using MetaBIM in building and facility maintenance management.

5.0 The Impact of Amenities on Social Housing Tenant Satisfaction

Background

This case study highlights the importance of location in determining tenant satisfaction with social housing. Living in neighbourhoods with ample amenities such as schools, shops, parks and restaurants positively impacts social lives and reduces social illnesses such as loneliness. The location and accessibility of social housing are as crucial as its layout and management because they influence participation of families in the community, physical activity and overall health.

In addition, internal and external amenities, socio-economic and cultural backgrounds, and the perceptions and needs of the inhabitants influence residential satisfaction. There is a lack of criteria for quantifying amenity satisfaction in social housing and that satisfaction is subject to perception.

Objectives

The purpose of this case study was to achieve two main goals:

1. An extensive review of the available literature on the definition and various types of public and housing amenities.
2. Exploring the correlation between different types of amenities and satisfaction of social housing tenants. This may be achieved through a literature review or by directly surveying the tenants, as deemed necessary.

Objective 1. Definition of amenities and their importance in residential satisfaction

Amenities are elements that contribute to comfort and convenience. They play a significant role in determining household satisfaction and can only be improved through change in location. Amenities include employment opportunities, grocery stores, health care, education, public transportation, parks and libraries. The terms ‘amenities’ and ‘facilities’ are often used interchangeably. Amenities refer to elements that contribute to comfort and convenience, whereas facilities refer to spaces and infrastructures designed to facilitate activities. In the residential sector, amenities and facilities are spaces and infrastructure that provide comfort and support for daily activities in the community and its environment.

Objective 2. Types of public and housing amenities

A thorough review of the literature has revealed two distinct types of amenities – neighbourhood and household – that play a role in determining residential and amenity satisfaction. This finding highlights the importance of considering both neighbourhood and household amenities when assessing the overall level of residential satisfaction.

2.1 Neighbourhood/Community amenities

Neighbourhood amenities, which can influence residents’ sense of place and satisfaction, include safety and privacy, natural physical beauty/open spaces, food stores, pollution, proximity to public transportation, access to medical services, recreational facilities, education centres and other amenities such as community centres and places of worship. Environmental psychology theories suggest that desirable amenities include open spaces, recent construction, recreational facilities and proximity to waterbodies. In contrast, unpleasant amenities such as litter, noise, violence and unwanted land use can lower neighbourhood happiness.

2.2 Household/Dwelling/Properties amenities

Household amenities are permanent fixtures that are physically attached to a property. Examples of common household amenities in apartments include swimming pools, dog parks, rooftop terraces, fitness centres, theatre rooms, garages, balconies, bike storage, laundry rooms, fireplaces and playgrounds. However, these amenities are limited in social housing, even in condominiums. There are various types of household amenities that include access to neighbourhood and community amenities, size of living spaces, location of residence, privacy, design, features and maintenance. Figure 10 highlights factors such as proximity to community amenities, size of living spaces, design of the residence, privacy and overall maintenance of amenities.

Factors Affecting Residential Satisfaction

Residential satisfaction is a crucial aspect of an individual’s quality of life and is influenced by housing amenities, neighbours and neighbourhood facilities. This is an evaluation of both physical and intangible elements of residential environments. Research on residential satisfaction has been conducted since the 1960s and is divided into two main themes: housing and neighbourhoods. Homeownership, education, age, life cycle stage, adequate space, physical qualities of the unit, neighbourhood satisfaction and age of the housing unit have a significant impact on housing satisfaction. Similarly, neighbourhood satisfaction is closely related to housing content. Resident satisfaction constantly changes and is shaped by social factors.

Factor 1: Measuring residential satisfaction – factors and approaches

Neighbourhood satisfaction refers to the perception of comfort or discomfort experienced by residents within their neighbourhoods. It is measured by considering residents’ characteristics, housing characteristics and neighbourhood and community features. The theoretical foundation of neighbourhood satisfaction has remained unchanged since its conceptualisation in the 1960s.

Factors that positively influence neighbourhood satisfaction include proximity to natural areas and bodies of water, safety concerns and neighbourhood amenities.

The key factors influencing residential satisfaction are neighbourhood tranquillity, greenness, cleanliness and security. The location and condition of the neighbourhood were found to be more critical than socio-demographic traits in predicting residential unhappiness. Proximity and accessibility to amenities such as transportation, education, health care, retail and banking also play a significant role in determining residential satisfaction.

Neighbourhood satisfaction is positively correlated with life satisfaction, happiness and eudaimonia and is measured by objective and perceived environmental features. Geospatial data are typically used for the objective measurement of physical environmental determinants. It includes the neighbourhood’s proximity to the city centre, nearby amenities, public open spaces, green areas and the absence of traffic. Perceived environmental correlates include perceptions of safety, quietness, neighbourhood social cohesion, accessibility, public space quality and aesthetic quality.

Geospatial analysis in geographic information systems is a tool used to measure satisfaction based on distance to amenities. The analysis calculates the number of amenities within a 1,000 metre radius of each participant’s dwelling. It includes data from OpenStreetMap on amenity categories such as restaurants, cinemas, schools, post offices, libraries, theatres, banks and hospitals.

Factor 2: Measuring housing satisfaction – housing design innovation and socio-cultural context

Measuring housing satisfaction is an essential aspect of design innovation and advancement of housing projects. It involves evaluating the degree of end-user satisfaction for a specific housing unit located in a specific neighbourhood with socio-cultural amenities managed by institutional management. The goal of measuring housing satisfaction is to understand how living circumstances affect subjective wellbeing. Studies indicate that factors such as the quality of a building’s structure and design, size and internal space of the home, availability of amenities and cost of the home contribute to housing satisfaction. The location of a housing unit is also a crucial factor in determining a person’s satisfaction with their home.

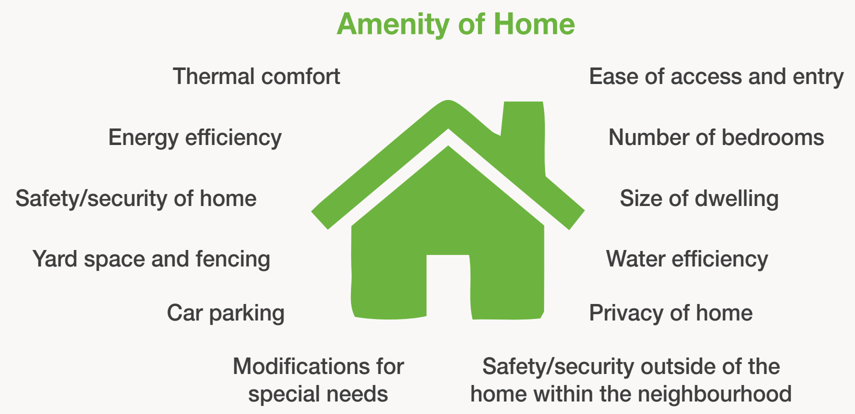


Figure 10: Amenities of Home

Australian National Social Housing Survey: Insights into Amenities Satisfaction

The National Social Housing Survey (NSHS) provides valuable insights into the experiences of social housing tenants in Australia. The survey, managed by the Australian Institute of Health and Welfare, is conducted every two years and collects information on tenants' housing histories, satisfaction with their social housing, services and amenities provided and use of health and community services.

The survey began in 1996 with public housing tenants and has since expanded to include community housing, state-owned and managed Indigenous housing and Indigenous community housing tenants in Queensland. In addition, the NSHS measures the tenants' opinions of amenities by considering their importance and whether their needs are fulfilled.

Descriptive results from previous NSHSs show that tenants' overall satisfaction differs according to:

1. geographic factors such as state/territory and remoteness
2. demographic characteristics such as age, Indigenous status, disability and whether there are children in the household
3. housing factors such as housing program, dwelling condition and overcrowding
4. Tenants' previous housing experiences and transitions into social housing. For example, the type of dwelling they had previously lived in and how long they had lived in social housing.

The housing experience and satisfaction of tenants are affected by numerous interrelated factors, some of which are specific to certain locations or housing programs. When two populations have different levels of satisfaction, determining the underlying causes of the multiple factors at play can be challenging. Regression analysis helps consider multiple factors and determines which factors contribute to differences in satisfaction.

Overview of Current Approaches to Measure Amenities Satisfaction in Social Housing

Research indicates several methods to measure satisfaction with residential, neighbourhood and household amenities. These methods include surveys, questionnaires, open-ended interviews, focus group discussions and regression analysis. The methods used vary depending on the type of amenity being measured, the location and target population. For example, the American Housing Survey is a national survey that provides information on neighbourhood quality and satisfaction. At the same time, the NSHS in Australia measures tenants' opinions on housing amenities.

The Neighborhood Amenities Index in the United States (US) measures the proximity of neighbourhood amenities, such as grocery stores, restaurants and community parks. Other studies focus on measuring residential satisfaction with public housing, assessing end-user satisfaction and examining the effect of the housing environment on residents' satisfaction and happiness.

Table 3 summarises various studies on satisfaction with housing and neighbourhood amenities in Canada, the US, South Korea and Australia.

Table 3. Existing Approaches to Measuring Amenities Satisfaction

Title	Description	Type of Amenities
Neighbourhood asset mapping by the community (Canada)	The asset mapping section related to neighbourhood gatherings was adapted partly from the Hamilton Neighborhood Action Planning Toolkit, Tool B – Asset Mapping. View Hamilton's Toolkit.	Neighbourhood amenities • Shopping malls/centres • Grocery stores • Markets • Restaurants, cafes and bars • Entertainment centres
American Housing Survey (AHS) (US)	AHS is the only national dataset that includes neighbourhood quality and satisfaction, which can be identified based on nativity status.	Neighbourhood amenities Infrastructure and physical attributes • Community recreational facilities • Open green spaces within 1/2 block • Bodies of water within 1/2 block • Roads within 1/2 block need repairs • Railroad/Airport/4-Lane Highway within 1/2 block • Parking lots within 1/2 block • Safety amenities • Walls/fences surrounding the community
Social housing: Housing amenities – tenant ratings (Australia)	The NSHS provides insights into the experience of social housing tenants. Tenant opinions on amenities first require tenants to nominate amenities as necessary, and then judge whether their needs are met against these amenities.	House amenities • Ease of access and entry • Number of bedrooms • Size of dwelling • Water efficiency • Privacy of home • Car parking • Yard space and fencing • Safety/security of home • Modifications for special needs • Safety/security outside of the home within the neighbourhood • Energy efficiency • Thermal comfort
The Neighborhood Amenities Index (US)	Additive scale combined the six different measures of neighbourhood amenity proximity, with values ranging from 6 to 30 minutes. Higher scores indicate a lack of amenities nearby, while lower scores indicate a greater number of neighbourhood amenities. The index was collapsed into five discrete categories that divided Americans into the following types of neighbourhoods: very high amenity, high amenity, moderate amenity, low amenity and very low amenity.	Neighbourhood amenities • Grocery stores • Restaurants, bars or coffee shops • Gyms or fitness centres • Movie theatres, bowling alleys or other entertainment venues • Community parks or libraries
Residential Satisfaction Among Public Housing Residents Living in Social-Mix Housing Complexes: The Case of the Seoul Metropolitan Area, South Korea	This study analyses residential satisfaction among public housing residents living in social-mix housing complexes only in the Seoul Metropolitan Area. It shows that housing attributes and housing quality are positively related to residential satisfaction among public housing residents.	Housing attributes • Housing satisfaction • Housing condition Neighbourhood attributes • Access to neighbourhood facilities • Social characteristics • Environmental characteristics • Quality of neighbourhood facilities Household characteristics • Educational level • Age • Family income • Years of residence • Presence of school-aged children

Concluding Remarks and Recommendations

In conclusion, assessing household satisfaction with amenities is crucial for the design and advancement of housing projects. The goal of measuring housing satisfaction is to determine how a person's living circumstances affect their sense of subjective wellbeing. This research identified several approaches to measure satisfaction with residential, neighbourhood and household amenities including surveys, questionnaires, interviews and regression analysis. The results of these studies suggest that multiple factors influence housing satisfaction including housing attributes, neighbourhood characteristics, public facilities and socio-cultural amenities. Based on this case study, the following remarks and recommendations are made:

1. Subjective perception drives residential satisfaction, which is mainly based on residents' perceptions rather than their actual living conditions. Subjective measurements such as perceptions are better indicators of satisfaction than objective measurements. The presence of nearby amenities has a strong impact on residents' happiness in a neighbourhood. Routine performance evaluations in the housing sector are necessary to improve our understanding of residents' needs and expectations.
2. Socio-cultural influences on desired neighbourhood amenities: Amenity satisfaction varies depending on cultural background, with native-born residents preferring recreational amenities such as proximity to waterbodies and open spaces, while foreign-born residents prefer functional amenities such as proximity to highways and business centres. Safety is the most critical dimension and proper street maintenance is the most significant physical indicator. Quality health care and educational institutions are essential components of community infrastructure in the functional dimension. Housing and neighbourhood preferences are determined by locational attainment, status attainment, country of origin and assimilation.
3. Flexible measurement criteria: The criteria used to measure satisfaction with amenities should be flexible and comprehensive regarding the perceptions and needs of inhabitants.
4. Accounting for multiple factors: When measuring housing satisfaction, multiple factors must be considered including geographic factors, demographic characteristics, housing factors and previous housing experiences.
5. Focus on neighbourhood amenities: The location and accessibility of neighbourhood amenities such as recreation, shopping and public transportation have a significant impact on housing satisfaction and wellbeing.
6. Socio-cultural amenities such as schools, health care and job opportunities should also be considered in the assessment of housing satisfaction.
7. Use a multidimensional approach: A multidimensional approach such as surveys, questionnaires and interviews should be used to measure housing satisfaction.
8. Data-driven techniques can also be used to measure the accessibility of geospatial amenities. The multi-source spatial data included demographics, road networks, community buildings, points of interest and census data.

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Find out more:

Project webpages (including link to YouTube video):
Digitally Enabled Asset Life-cycle Management
https://sbenrc.com.au/research-programs/2-82/

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