THE SYSTEMATIC DEVELOPMENT OF A SOFTWARE ENVIRONMENT FOR BUILDING APPRAISAL IN THE BUILDING RENOVATION INDUSTRY

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In Europe, 50% of construction work is undertaken on existing structures. In Ireland that proportion is 30%. The EU Conservation of European Cities Programme has provided substantial funding to several renovation case studies in Cork City, Ireland. Initial research undertaken by the Building Energy Research Laboratory on these case studies in Cork City has identified that there is a need for an integrated approach to building renovation. Such an integrated approach can be facilitated by providing a framework for information exchange between the professionals involved in building renovation. The objective of this research is to describe formally the requirements for a Building Appraisal Software Environment (BASE). The paper focuses on the role of the Appraisal Engineer and describes in detail the development of a Multimedia Database System with Decision Support and IT facilities that will aid the Structural/Conservation Engineer.

Keywords: .Building appraisal, database management systems, renovation, software engineering & object-oriented technology, UML

INTRODUCTION

In Europe 50% of construction work is undertaken on existing structures and in Ireland that proportion is 30% (McMahon 1997). Refurbishment and renovation of old, historic buildings has now become an important aspect of the building construction industry. The attitude towards repairing existing structures has changed. Greater consideration is given to the built environment where redevelopment or developing a green field site is no longer the automatic choice. Approaches to building re-use include renovation, restoration, conservation, repair, rehabilitation, conversion, refurbishment and alteration. The approaches may vary somewhat, but the unifying concept for building re-use is the same (Markus 1979). A strategic initiative has been undertaken in Cork City with assistance of the EU, whereby the Corporation is promoting the re-use of existing buildings through renovation and conservation. Several projects implemented under this strategy were reviewed by Building Energy Research Laboratory. It was proposed that an integrated approach among professionals towards building renovation is needed. Renovation projects require a broad range of professional expertise. Professionals require more specialised training and knowledge in renovation and conservation in order to carry out successful projects. Building appraisal is one of the most important work processes in renovation and is the responsibility of the Structural/ Conservation Engineer. Unless the structure

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of a building is sound, all other building features will not last. A systematic appraisal process is necessary for successful renovation project completion.

The objective of this research is to develop a Building Appraisal Software Environment (BASE). The software environment comprises of a database management system, expert guidance through multimedia presentation, and a decision support system using Case-Based Reasoning (CBR) techniques. This paper documents the systematic development of a section of the database management system. The multimedia system and the case study database are also under development and the decision support system will be the focus of further research. The research approach taken is as follows:

- Identify the state of the industry background.
- Identify the design team members involved in renovation.
- Identify current work practices, in particular the work of the Structural/Conservation Engineer.
- Highlight difficulties in the renovation process.
- Develop improved work practices through IT with respect to the work of the Structural/Conservation Engineer.

INDUSTRY BACKGROUND

The government has recently passed legislation to enhance the protection of the architectural heritage in Ireland. For many years old historic buildings were lost due to redevelopment, but the past number of decades have seen a change in attitude towards renovation and conservation. Through the initiative of EU programmes and Urban Renewal Schemes, the urban fabric of many European Cities is undergoing renovations and in Cork City, the Corporation has undertaken major renovation projects as part of the Conservation of European Cities Programme. Cork is the second largest city in the Republic of Ireland and has a rich concentration of built heritage. The city has 600 listed buildings, the majority of which are low to medium rise masonry structures, dating from the18th and 19th centuries (Cork Corporation *et al.* 1994). While recognising the richness of Cork's built heritage, much of what survives is in a poor state of repair. Among the reasons for this are low demands for space, insufficient encouragement of repair, lack of appropriate skills amongst professionals, tradesmen and labourers, and insufficient general public support for historic conservation. This had led to a preference for new buildings over refurbishment and a consequent lack of incentive to repair (Cork Corporation 1997). To combat these problems, the Corporation has implemented a major urban development plan for the City, which incorporates conservation, renovation and urban regeneration policies.

BUILDING RENOVATION TEAM

Renovation and conservation projects require a broad range of professional expertise. Building renovation work includes methods of appraisal, conservation, redesign, alterations and repairs from each profession's perspective. Figure 1 identifies the main renovation team members involved. There is a need to facilitate better communications and to develop a formal framework for information exchange among renovation team members. A broader knowledge of renovation issues such as conservation, legislation and planning laws, construction methods, skills, training and

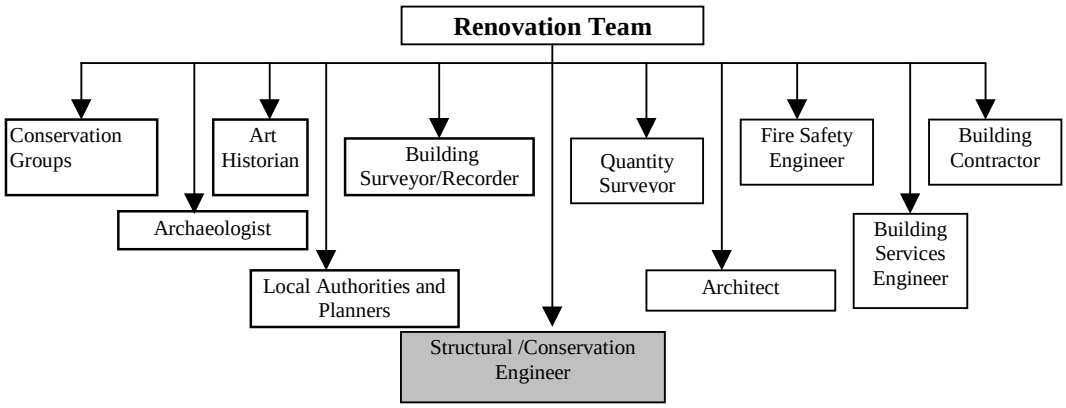

Figure 1: Building renovation team

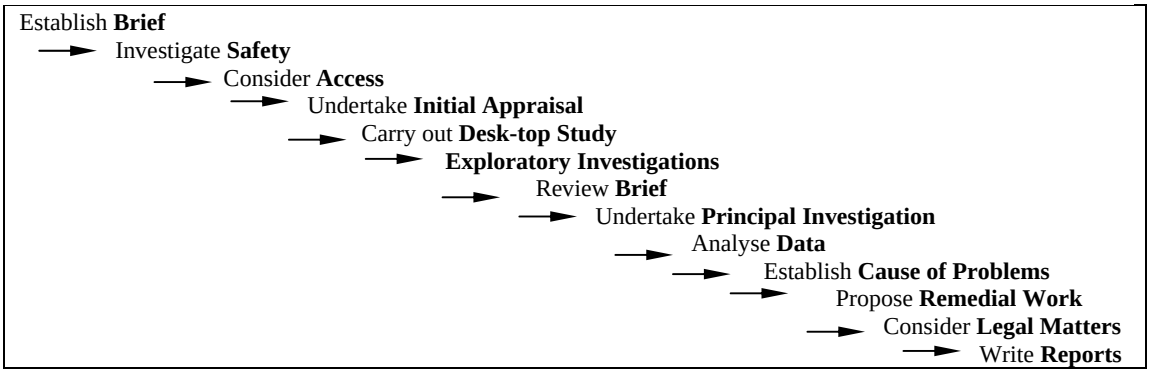

Figure 2: Appraisal process

materials; and the use of a standard building appraisal and recording process are required. Greater understanding of these issues will lead to more efficient work practices in renovation projects.

BUILDING APPRAISAL PROCESS

The building appraisal process is fundamental to the success of any renovation project because renovation work is difficult to assess accurately from the outset of a project. The client will require a detailed account of the building condition and a specification of the costs of renovation works before any work commences. Structural Appraisal is a process that usually encompasses the following; document research, inspection, measurements and recording, and structural analysis (Beckmann 1995). In Cork City a practical approach to building conservation has been taken. Practical and sensitive repairs or remedial works are specified rather than adopting heavy-handed measures. The structural/ conservation engineer takes such an approach particularly when working with traditional structures. Correct decision making is vital in order to protect the building fabric, therefore a systematic approach to building appraisal, problem diagnosis and remedial work is proposed. There are numerous documented approaches to building appraisal (BRE 1991,CIRIA 1986, Institution of Structural Engineers 1980, Parkinson *et al.* 1992). Figure 2 outlines a standard building appraisal process (Holland *et al.* 1992). Each phase of the appraisal process involves carrying out a set of procedures.

The initial stages of research have shown that a formal appraisal process is necessary for successful project management. The process also forms the basis for a strategic project management plan. The process identifies client requirements, investigation procedures, building conditions, remedial works and specifications and costings. The

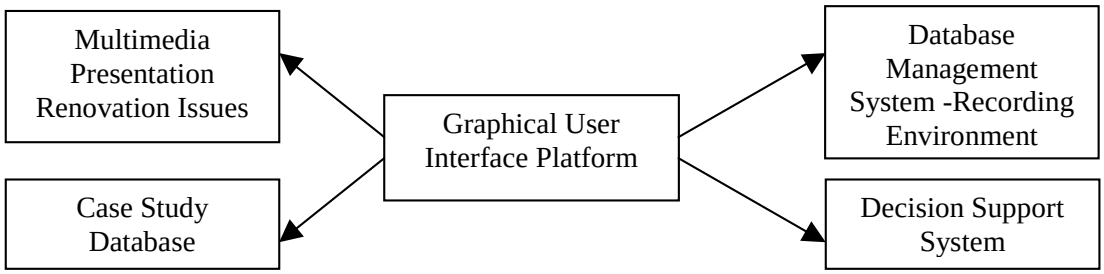

Figure 3: Integrated information system

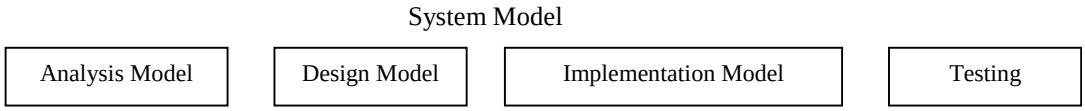

Figure 4: Phases and models in a traditional software life cycle

guidance of a standard appraisal work process will make building inspection and decision making easier for the structural/conservation engineer. The potential use as a renovation project, site management tool is also evident. Incorporating the work processes, of the other team members into the software environment will create a single work environment for information exchange. This paper describes the development of the Building Appraisal Software Environment (BASE) and specifically focuses on the specification, analysis, design and implementation of the 'Initial Appraisal' phase of the overall appraisal process (See Figure 2).

SOFTWARE ENVIRONMENT

Communication and information exchange are central issues in the appraisal process. The development of a multimedia software environment can provide a suitable framework for building appraisal. IT provides a reliable means of supporting the exchange of information on renovation projects, between team members. The software environment proposed in this research will provide the following (Figure 3):

- **A database management environment**
  - A database management system for renovation projects whereby the associated parties can have direct access to project details;
  - A building recording environment whereby building appraisers can accurately detail and record project appraisals;
  - A report generation facility, which is an essential part of the appraisal process.
- **Expert guidance**
  - A best practice guide to appraisal and renovation of buildings;
  - Instant access to relevant information through the use of multimedia presentation; database systems and internet connection;
  - Case study material on renovation projects;
  - A library of 3D models representing simulations of building defects/failure.
- **Decision support**
  - A data analysis & decision system that will model building appraisal data and provide analysis, diagnosis and recommendations. In order to facilitate decision support in the Building Appraisal Software Environment, a case-based reasoning approach is proposed (Watson 1997). The decision support system requires detailed consideration and will be the focus of future research.

SOFTWARE DEVELOPMENT

Software Life Cycle

Formal software development consists of several phases that include analysis, design, implementation and testing. These phases are known collectively as a software life cycle (SLC). Each phase of the SLC produces it's own model that consists of diagrams and specifications (Figure 4). Several SLCs exist. These include the "Slam Dunk" SLC and the Waterfall SLC etc. However, many of these cycles are limited due to the lack of feedback between phases. The SLC chosen in this research is the Iterative and Incremental SLC. Building system models is best done as a number of iterations; that is, instead of trying to define all the details of a model or diagram at once, the development is a sequence of steps, whereby each iteration adds some new information or detail. One iteration or a set of iterations can be treated as an increment of the system. System analysts require a notation in order to develop the process models and presently a standard modelling language known as the Unified Modelling Language (UML) is being developed.

Unified Modelling Language

UML is a developing standard notation for object-oriented analysis and design of systems that supports the iterative approach to software development. The unified modelling language (UML) is the successor to the object-oriented analysis and design methods that appeared in the late '80s and early '90s (Booch 1994). It unifies the methods of Booch, Rumbaugh and Jacobson and is expected to be the standard software modelling language for the industry in the future (Fowler *et al.* 1997). UML contains notations and rules that make it possible to express object-oriented models. UML can be used in the different phases in the development of a software system, from a requirements specification to the testing of a finished product. UML specifies different diagram types. Use Case diagrams enable the modeller to begin with a business level analysis of the scenarios of a system. Class diagrams model the static behaviour of a system. Sequence, collaboration, and state diagrams model the dynamic behaviour. Component and deployment diagrams model component grouping and distribution of objects.

CASE TOOLS

Using a complex language such as UML requires the support of CASE tools. System Architect™ was used for the development of the Building Appraisal Software Environment (BASE). This CASE tool provides a graphic environment that supports UML. It can be used for creating diagrams; acts as a repository for model information storage; supports navigation through models; supports multiple users and supports code generation for a variety of languages and database management systems e.g. C++, JAVA and Microsoft Access™. The tool also has the ability to reverse engineer existing code and to integrate with other development tools (System Architect 1998).

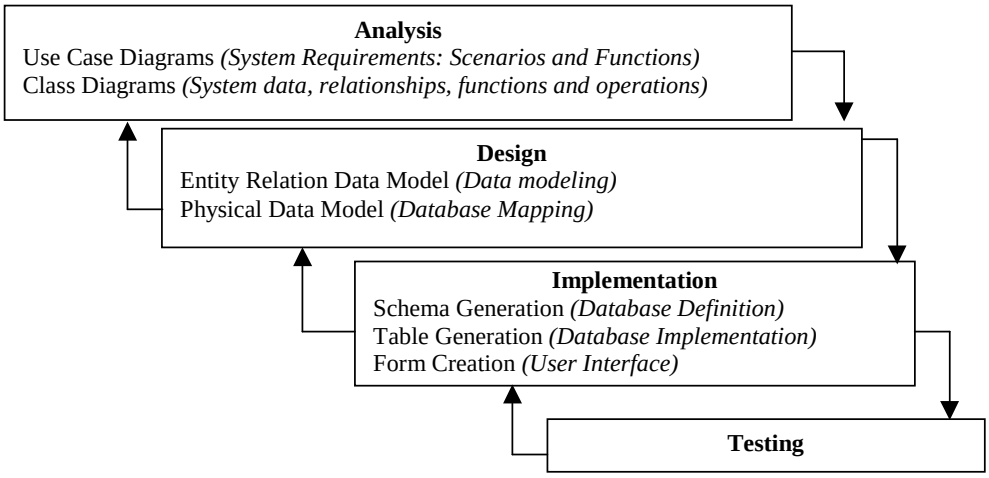

Figure 5: Software development process

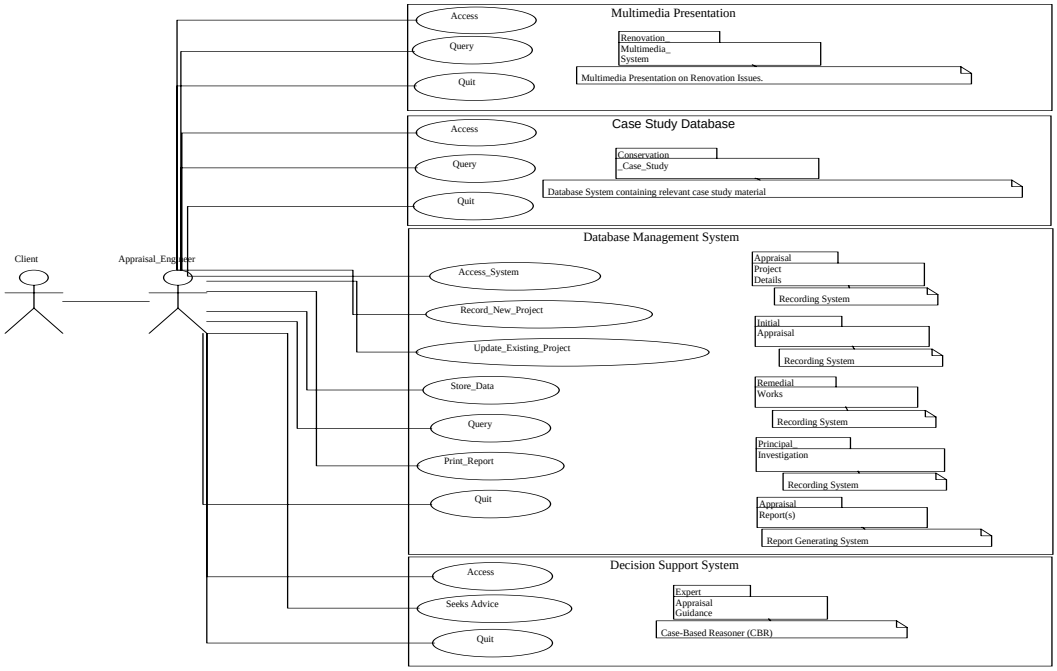

Figure 6: BASE use case diagram

BASE DEVELOPMENT

Figure 5 depicts the SLC used in developing the Building Appraisal Software Environment (BASE). UML is used to model each of the phases in the SLC and System Architect™ is used to implement each of the models within each phase.

Requirements Analysis

The requirements analysis implements use cases, business processes, or plain text to describe the functions of a system. The system is described from a top level; it does not delve into how things are done technically. By knowing the system requirements, a use case diagram is created for the system. Figure 6 depicts the use case diagram for the overall environment. However, this paper focuses on the initial appraisal stage of the Database Management System. Figure 7 depicts the use case diagram for the

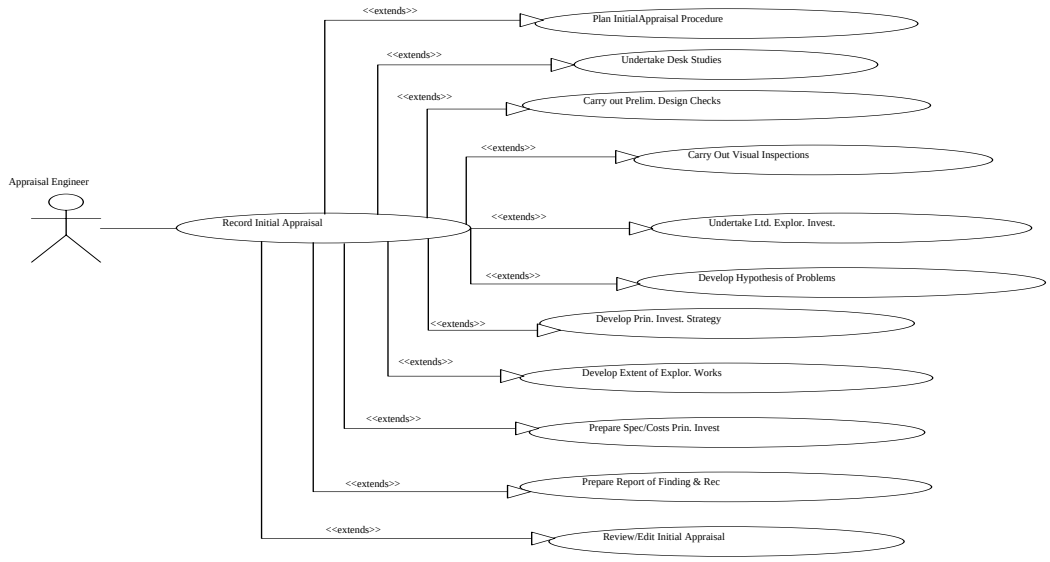

Figure 7: Initial appraisal use case diagram

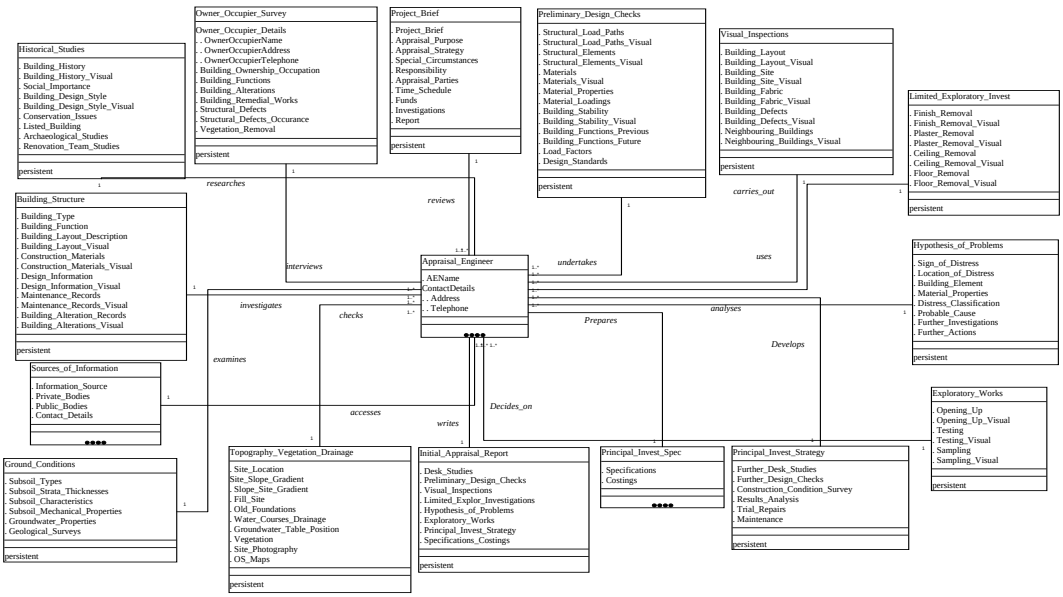

Figure 8: Initial appraisal process: class diagram

scenarios that arise in the initial appraisal system. Detailed steps are documented for each scenario in the analysis, which are specified later in the analysis phase.

SOFTWARE ANALYSIS

The analysis phase generates models of the problem domain: classes, objects, and interactions that model real world entities. An analysis should be freed from any technical or implementation details. It should contain an ideal model and deal with acquiring the necessary knowledge about the domain. Activities in the analysis include: acquiring domain knowledge from the requirements specification; defining system functions from Use Case modelling; determining suitable classes for modelling; relationships between classes are determined. The scenarios of use case diagrams are modelled in sequence or collaboration diagrams. Figure 8 shows a class diagram for the 'initial appraisal' process. Developing these diagrams was an iterative

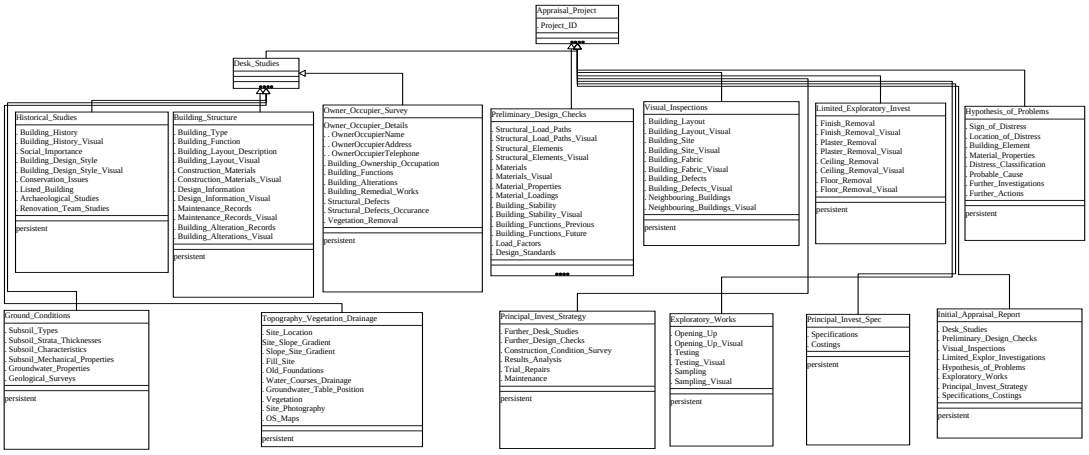

Figure 9: Initial appraisal database: class diagram

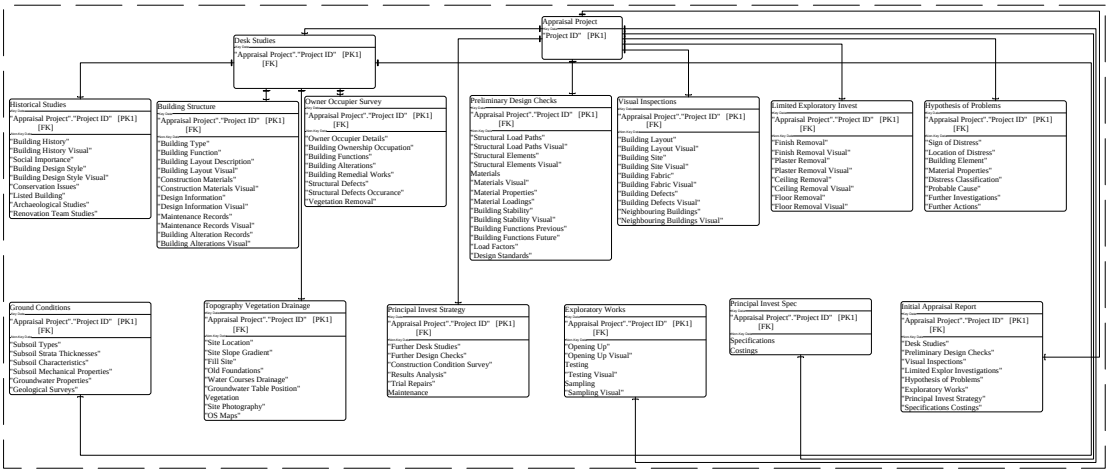

Figure 10: Initial appraisal logical entity relation diagram

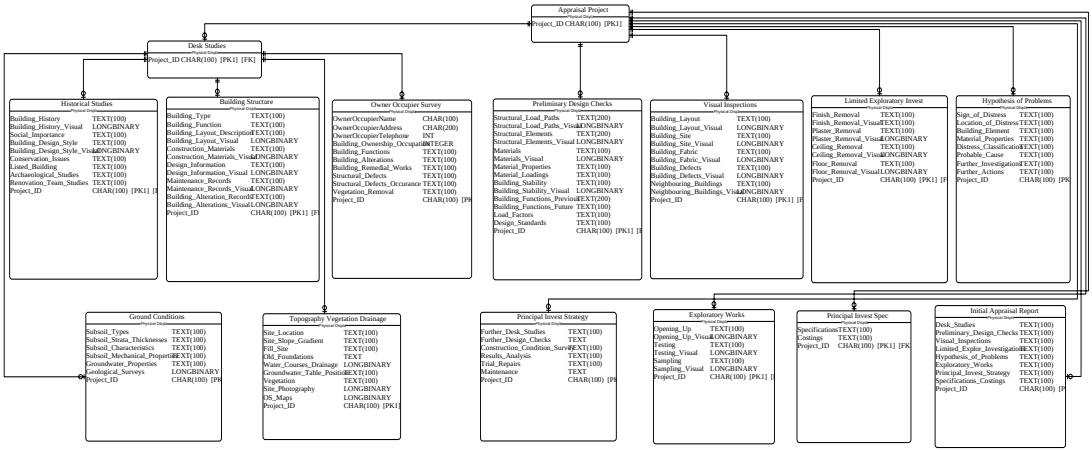

Figure 11: Initial appraisal physical data diagram

process and diagrams constantly changed in order to produce a working model. This model was in turn used to develop a class diagram for the 'initial appraisal' database (Figure 9).

SOFTWARE DESIGN

The design is a technical expansion and adaptation of the analysis result. The classes, relationships, and collaborations from the analysis are complemented with new

elements, now focusing on how to implement the system in a computer. All the details of how things should work technically and the constraints of the implementation environment are taken into consideration. Typical activities in the design included: an architectural phase, during which the analysis classes are divided into functional packages. New packages for technical areas such as the user interface, database handling and communication are added; the detailed format of the output from the system is specified including user interface and reports.

Object technology allows a complete model of the system to be created. Object modelling does not restrict the use of a relational database management (RDBMS) system in implementing the object model (O' Brien 1994). In order to produce a working software model, Microsoft Access™, was chosen to implement a component of the system. Access was chosen because of its wide use and availability as part of the Microsoft Software range and Microsoft Access has a quick development time (Norton 1997, Liskin 1997). By developing the system using object-oriented technology, our design phase involved translating the class model into a logical entity-relation data model, which in turn was developed into a physical data model for database implementation (Figures 10 & 11).

Software Implementation

The implementation activity usually involves the writing of the code. This step involves translating the design diagrams and specifications into syntax of the chosen programming language. The physical data model is used to generate schema. Schema is a description of the overall logical structure of a database, expressed in a special data definition language (McFadden *et al.* 1994). The generated schema is imported into the database using an 'open database connectivity' (ODBC) connection. The created database forms the main storage unit for information. Figure 12 depicts the database tables that are defined from the generated schema and Figure 13 displays the table structure showing field names and data types. Using the database requires an interface. The main user access is by form entry. Forms play a crucial role in the entry and update process, and Access provides a design tool you can use to create a wide variety of customised forms (see Figure 14).

System Testing

In order to improve the system models, several iterations of database implementation were carried out to evaluate the data table. Tables were checked for layout, content and relational database design criteria. Extensive software testing has not been undertaken as the research and development is still at an early stage, but it is proposed to organize a seminar workshop where renovation experts can evaluate the software.

RESULTS AND CONCLUSIONS

This phase of research into building renovation and IT has shown that:

- BASE has the potential to serve as an effective project management tool in building renovation projects.
- The provision of an integrated software environment for building appraisal will result in more efficient work practices in building renovation and conservation.
- Systematic software development is necessary so that quality software can be developed, extended and maintained.

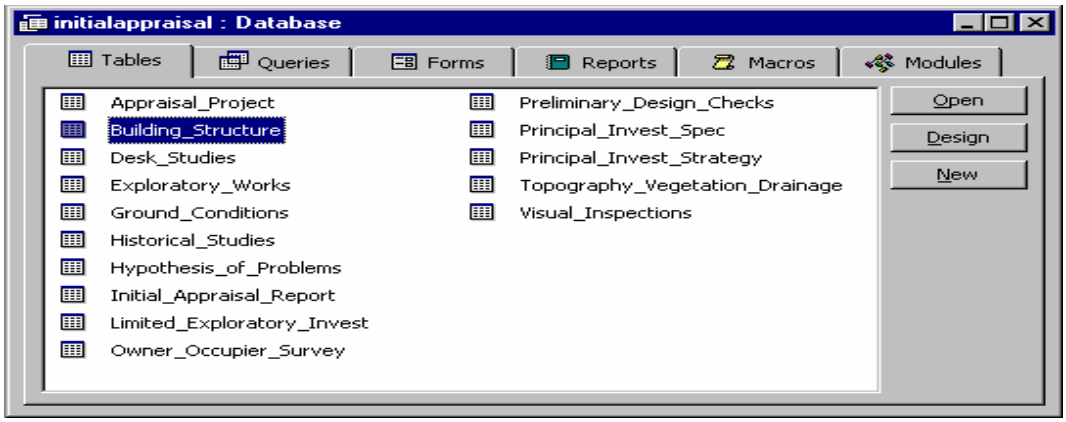

Figure 12: Initial appraisal database

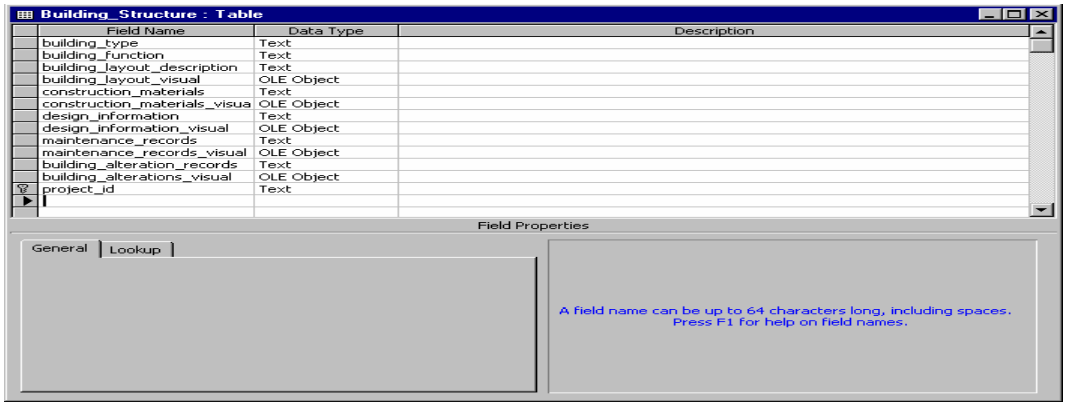

Figure 13: Initial appraisal database: building structure, table design view

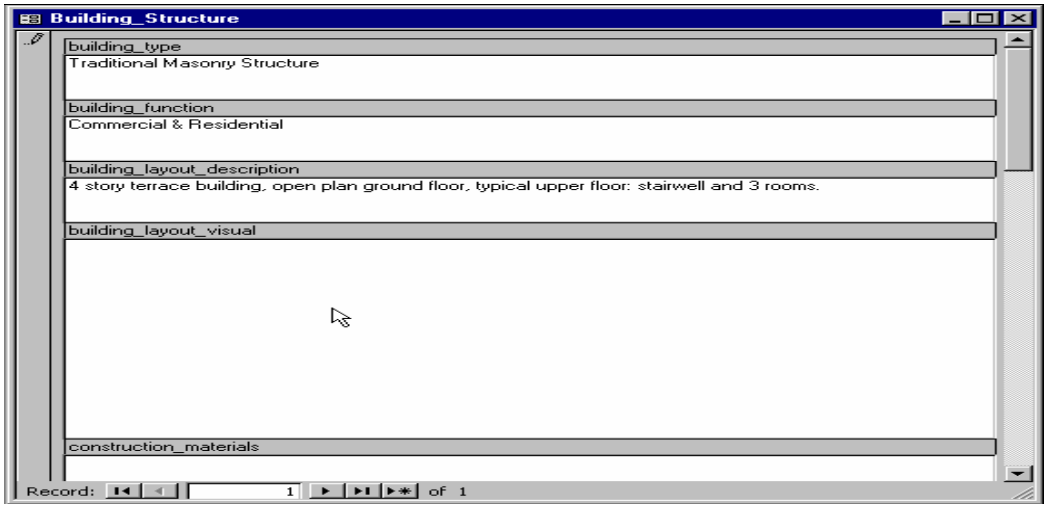

Figure 14: Building structure data access form

- The use of a standard notation (UML) and a development process allows software designs to be understood by developers across the industry and implemented in a variety of software languages.
- CASE tools are an important aspect in software development. They can support the modelling language, the process and the programming language used for system implementation.
- The future research and development objectives will be to integrate the system with other work processes of the professionals involved in building renovation; develop the decision support system using case-based reasoning techniques and to further enhance the existing system.

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