KNOWLEDGE BASE OF COMPONENTS AND CONNECTIONS FOR A CAD/CAM SYSTEM

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ABSTRACT

The purpose of this paper is to describe a CAD/CAM system conceived at first for the assembly of mechanical parts, which can be used in other areas, particularly in construction.
We describe here the organization of the core of the system which is composed of a set of knowledge bases (technical bases which are related to an area and theoretical bases).
We also show the different types of links existing among objects described in the bases.
The use of different objects is made by a set of software tools based on IA and OOP concepts.
A variety of tools is thus used : physical phenomenon simulation, 2D and 3D graph representation, finite element methods ....
At each level in the decomposition of the construction's into subsets, specification constraints and successive refining of the knowledge restrict the range of solutions.
By its modular aspect, this system allows to resolve all construction problems : structure, assembly, electricity, ...

Key words
Knowledge base, OOP, CAD/CAM, assembly, construction, functionnal connections.

Introduction

The building trade is one of the sectors where the introduction of robotized works seems to be the most difficult, because of its specificity (not very likely to be broken up, not very repetitive work, moving environment ...). On the other hand, the development of computer science and automatics allowed better component-making and reduced technical problems.

.This was observed by K. Oey in [Oey85]. The author gives us a brief review of expert systems used in building trade in 1985. Most of the developments are directed to the so called "front end" and "diagnose" systems. It will be time to conceive an expert system for the design process.
The idea is a knowledge base with level in form of clauses.
In a way, this idea is partly similar to our object classes. The OOP gives most flexible concepts for the representation of this knowledge base and their management.

.In [IMT85], the authors present an original expert system for the design of architectural exteriors.
The construction is considered as an assembly of different kinds of exteriors which have specific functionalities.
The knowledge base is developped in Prolog. It can be a subset of our CAD/CAM system construction.

.For a few years, the CSTB has worked on the use of high tech in the building trade [CST86].
Among implemented studies, two are particulary attractive :
- The use of OOL for the CAD in [CRA86]. The data are adapted to construction ; the system proposes some procedures for coherence management and interactive communication tools; two application areas were chosen : thermic and structure calculus.
- Robotics in construction is a project started in 1984 by JL Sallagnac [Rus85], [Sal87].

The ENCORE project [Zdw 86] of Brow University consists in the production of a very important Object Oriented Data Base that allows to include all programming objects used by multiple users in a distributed environment.
This is also described in [KoC86] and it has similarities with our organization of the knowledge base in the system.

Our system was conceived at first as a CAD/CAM system for the assembly of mechanical parts [BCD88].
In this paper, we want to show that it can be used in other areas than mechanics (e.g. in construction).

We first present the organization of knowledge bases (the core of the system), then we briefly describe the approach used for the construction design.

I Objetc's organisation in knowledge base

We differentiate two types of knowledge bases : technical bases (they are linked to a particular area - for example mechanical area in the first conceived system- but also electromechanics, electrotechnology, ...which are closely related to mechanics) and theoretical bases which are necessary whatever area is chosen for the application.
For example, we have to describe the different solids and connections which compose mechanical or architectural assembly (connections can be set between components of a same areas or between several areas).
We use three sorts of links between the objects of the bases : apo (a part of), ako (a kind of) and isa (is a).

I.1. Technical base

We distinguish, here, two parts, according to the type of link which joins the objects of these base.

I.1.1. ako type links

Figure 1 gives an example of such a base. It's related to a particular area (construction) but can integrate some different sub-areas (masonry, plumbery, ...).
This base makes a catalogue of all components in construction. The figure only presents the first level of the decomposition. At the second level, we find all components used in practice and considered as indivisible.
For example : a plumbery component for tap alimentation can be of different kinds : simple tap, mixing tap, ...Among mixing taps, some of them are used for shower, other for bath or for wash-stand. Then, among the shower mixing taps, we can find different kinds of them which are indexed and for which we have a precise reference.
In fact, this base gives us the complete catalogue of components used in construction (or in the area for which the system is developed) with the associative choice methods of each object.
This part of the base is created at first but can be extended in case of technological innovations (a new kind of heating system or new home appliance, ...).

I.1.2. apo type links

This base has two aspects : definition and use.

a. definition aspect (static aspect)

It describes the different existing kinds of construction (building, separate house, church, school, ...). For each sort of construction, it gives us the different parts of it (inside ones given by level and the outsides which can be considered as open "parts" of the construction : e.g. patio for a building).

b. use aspect (dynamic aspect)

An example is given by Figure 3. The base described in (a) allows us to build this sketch.
We have chosen here the example of a four level building with one level in the basement.

The building is first decomposed by level and links between them (four stories, a level in the basement and links between floors : staircase or lift, or the both).

Each level is self decomposed according to its characteristics :

- level -1 : if cellar or garage, that will determinate the type of materials to be used.
- level 0 : it's the ground level, so we can find some particularities like letter-box, entrance-hall, ...
- level 2 : this is the last level, so we find here (for example) particular ceiling depending on chosen roof
- level 1 : if the construction is a for dwelling one (it could made for .offices, ...) it can be divided into several flats and for each of them we have a number of rooms of any type (bedroom, bathroom, ...). Each room is then decomposed into different.one-level components (roof, wall, ...). At last, each component of a bathroom wall (for example) has inherited the bathroom characteristics, the flat ones and the type of the building (luxury or low rent dwelling). That will cause a special design for walls and different parts of it (plumbery, electricity, covering, appropriated structure and insulation). For example, the structure can be more or less durable according to the type of the building and particulary its total cost that is given by the specification.

In fact, all the decomposition is directed by specifications. We'll see in paragraph II which different steps of the design process allow to achieve this decomposition and how the links are established between objects of the base described in this paragraph.

I.2. Theoretical base

I.2.1. apo type links

These are two bases that exist whatever the application area we choose (mechanical, construction). A part of them is given by Figure 2.

a. connections base

It is the catalogue of the elementary and compound connections (are-free). At each connection is associated its geometry that defines the relative positions between components.

.elementary connections [AFN85] : pivot, slide, spherical, ...

.compound connections : they are implemented by association of several or/and parallel basic connections ; they also can be special connections.

b. solids base

Through geometrical characteristics of all solids, this base allows the representation of the system components : mecanism to be assembled or construction to be built.
The solids are divided into three categories : 3D, 2D and 1D solids.
In construction, we will be able to link post and bean (figure 1) to 1D rectilinear solids (instanciation). In the project elaboration stage, ako links are placed between the components of the building and the associated type of solid.
Each component part (e.g. a post) will inherit all the characteristics of its associated solid (e.g. : 1D lineic, rectilinear and associated representation methods).

I.2.2. apo type links

a. connections

Each elementary connection can be implemented by serial or parallel association of connections. For example, a pivot connection can be directly or by parallel association of a spheric and linear annular implemented. So we define here an apo type link.

b. solids

Each indivisible component is characterized by its type (special, standardized or normalized).
If it's special, it's composed of all its functional and linking surfaces.
If it's standard, it's composed of functional and casing interfaces.

In the project development stage, two apo links are then fixed between a connection and two functional surfaces of two different solids (in case of special solids). A connection consists in bringing two solids into contact.

Example : connection by placing different component parts of the floor (Figure 4 and paragraph II).. One of those connections is done by placing the tiled-floor on the flagstone).

II. Décomposition of the design process

In this paragraph, we work on Figure 4 (the assembly of a floor) in order to show the different stages of the décomposition

We also exhibit different kinds of links that appear during the design process.

The design process starts from functional specifications. The feasability study allows to identify sub-systems and internal and external connections. The nature of the connections permits to determine the necessary domain for their study (electricity, masonry, plumbery, ...).

Functional specifications allow to determine a minimal diagram. It's composed of component parts of the edifice to be built. They are those transmitted by the architect : walls, ceilings, floors, ... The base described in I-1-2 is thus used (its first level)

The <u>technical principe diagram</u> built by decomposition of each component allows us to do the necessary calculus (resistance, thermal, noise, ...) in order to optimize the choices.

For example the floor can be built by assembly of several components for the structure part. The base discribed in I-1-2 is thus used at its second level.

Then we define connection interfaces in order to obtain a <u>functional diagram</u>. We set the links between connections and validate them after realization technics choices.

At last, the <u>architecture scheme</u> considers linking surfaces. We choose here an implementation technique, connection surfaces are sized by structure methods. We also check assembly and manufactury feasability.

If the choosing implementation techniques is the use of motor in order to secure components (building of the flagstone), we do not have to size components.

(In the base, each connection has its associated implementation techniques).

At each stage of the design process, constraints (technological, cost, ...) coming from specifications eliminate solutions.

The object-oriented programming is fully justified by the structuring of all objects of the base (components, connections, ...), to which the necessary methods are associated (calculus, expertise rules, ...).

The access to the object is easy, because of different link types existing between the bases.

E. Chouraqui and P. Durgerdil in [ChD 86] also present an Object Oriented methodology for the knowledge representation in architectural CAD. A software written in Prolog and implemented on the Macintosh is able to create and use a knowledge base based on this model.

The big project "Orient 84K" [IsT 86] is a part of the research on concurrent object-oriented systems.

We also have to take into consideration the parallelism expression in our research since our process must be conceived for parallel execution.

Conclusion

Among the construction robots checked up for the IIHT and the AFRI(Association Française de Robotique Industrielle), we note a lot of them used in traditional assembly operation like "rivet, weld, screw, put in, assemble, ..."

This comfirms us in the fact that the "component assembly" (generally speaking) can be applied to many construction work.

Our CAD/CAM system can well be used in order to develop a sub-system for assembly in construction.

This sub-system will have its own specific knowledge bases described in this paper.

We also study the most suitable OOL for this development.

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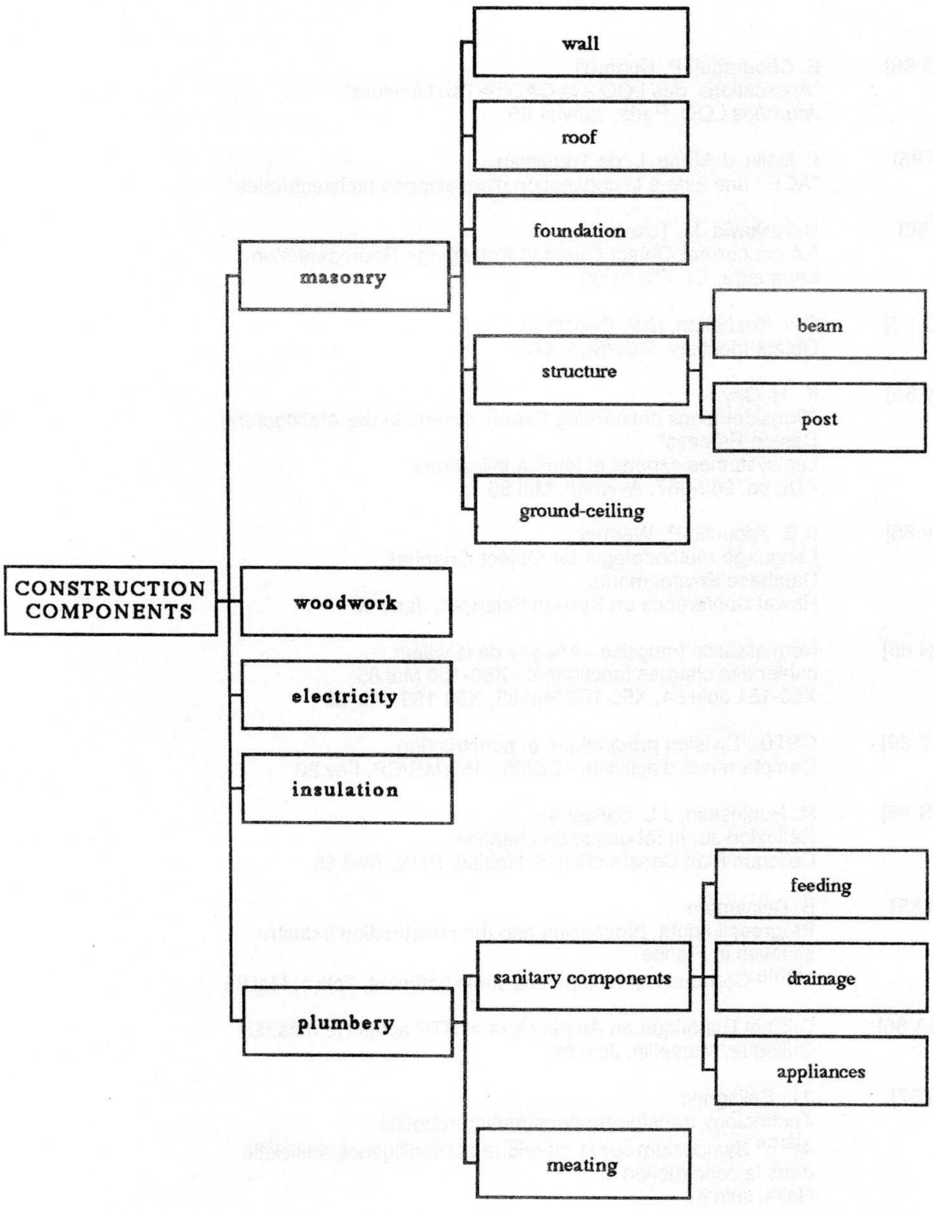

Figure 1 : a part of the technical knowlege base of components in construction (links : a kind of)

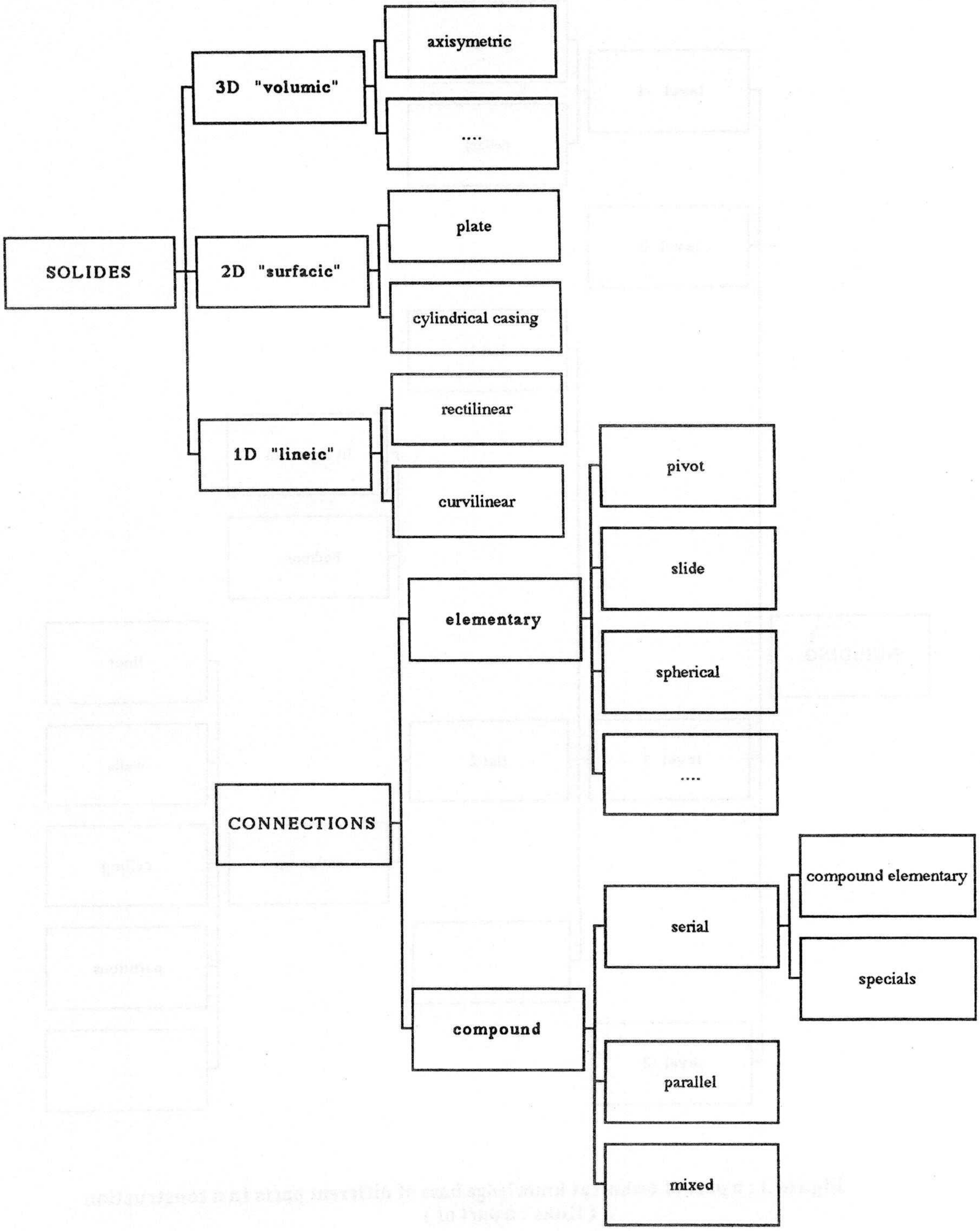

Figure 2 : a part of theoretical knowledge bases (links : a kind of)

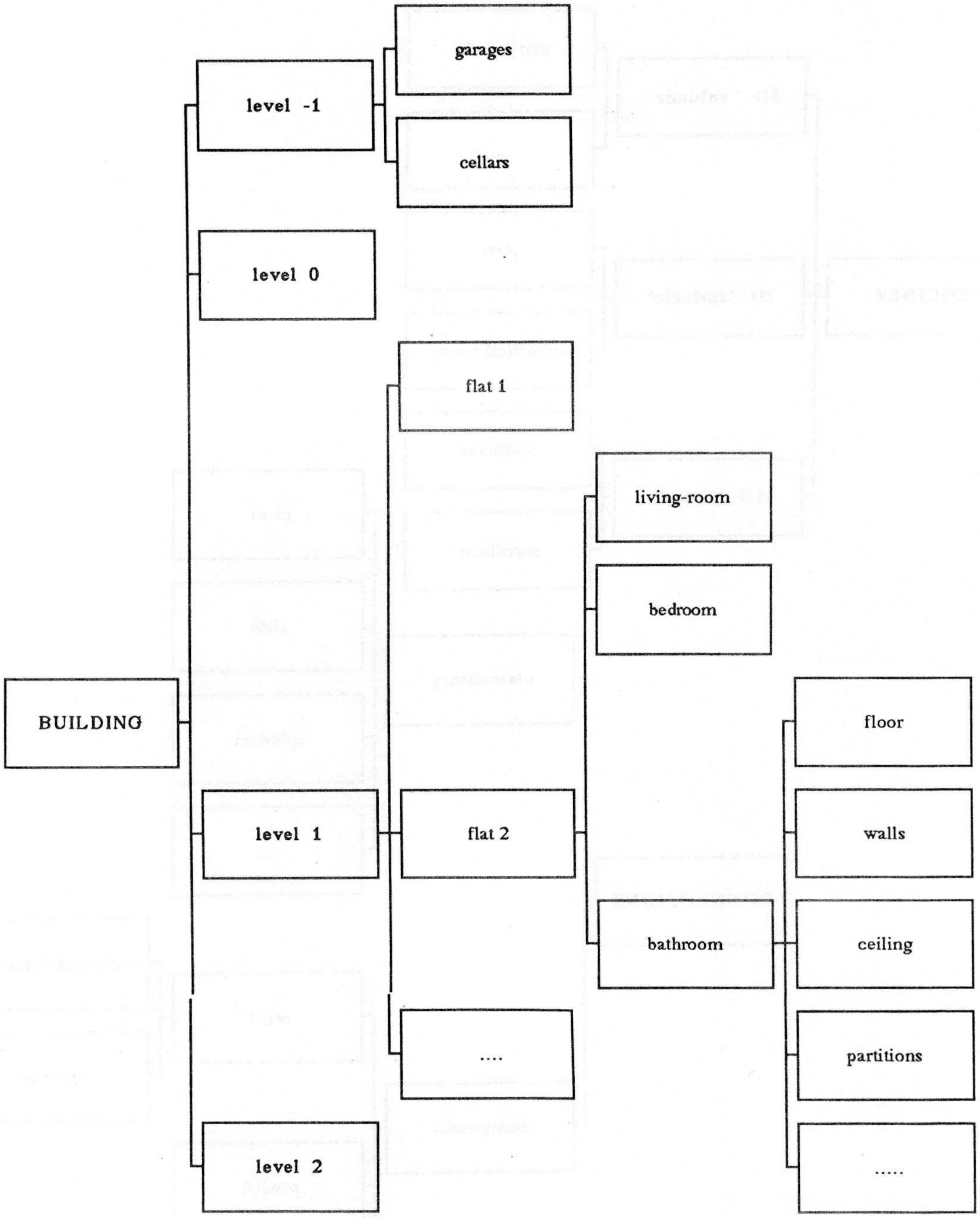

Figure 3 : a part of technical knowledge base of different parts in a construction (links : a part of)

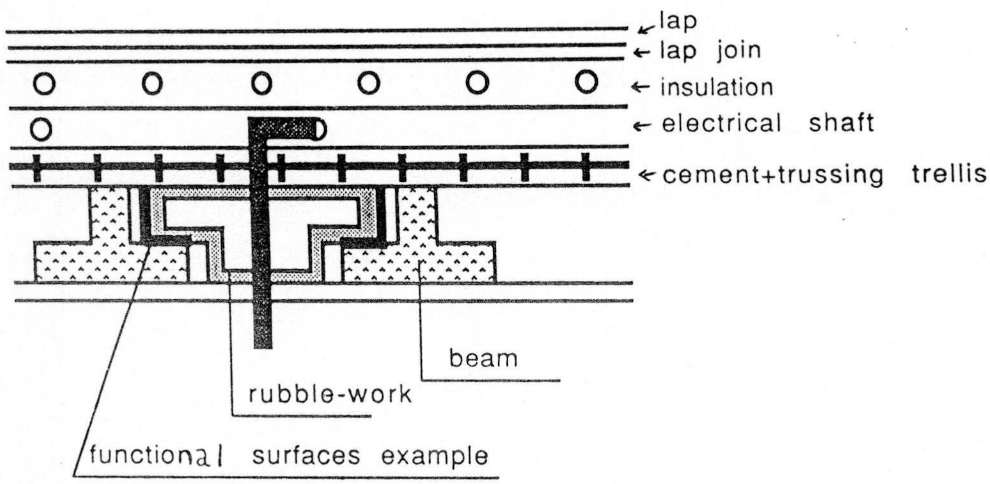

Figure 4:Components parts of a floor with ground heating