Design for Change
Flexibility Key Performance Indicators

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It’s probably not appropriate to make a joke about Open Building in the Netherlands.

But this is left of the Faculty of Architecture in Delft after an enormous fire last Tuesday, May 13.

The building partly collapsed too.

It’s a disaster for our faculty, for the 300 students and for my 800 colleagues.

The ancient library is gone, with a lot of unique and very valuable books.

The same counts for several collections of scale models of famous architects as Le Corbusier, Frank Loyd Wright and the Dutch architect Rietveld.

And of course the work of graduate and Phd students.

For the rest of the semester we have to teach and do our research in the open air.

Back to the basics.
My presentation consists of 4 main parts:
• Part 1 is about important trends in construction, especially with a focus on the future
• Part 2 is about Open Building, Flexibility and adaptability
• In the main part 3 I will explain the so called Flexibility Key Performance Indicators.

Talking about adaptability:
On the pictures you see all kind of different types of a specific Citroen car, each based on the same rigid frame.
An example of the best adaptability you can get.
Developments in the building sector show a number of trends all of which point to the growing importance of flexibility in buildings and the installations concerned. Such as:

- The long life cycle of buildings compared to the short life cycle of its functions
- The vacancy of buildings because they don’t longer meet the present requirements.
  For instance in the Netherlands we have a structural vacancy of office building of more than 15%.
  The same problem occurs with churches, old schools and ware houses.
- Another trend is the rapid change of user demands compared to the slow changing possibilities of buildings

And in addition there is the important trend towards sustainable building. Environmental problems and energy management are very much in the limelight.
There is an increasing pressure on society to develop and construct sustainable buildings.

In the Netherlands the economical contribution of the construction industry is only 5.1%.

Yet in the Netherlands the building industry contributes for

- 25% in road transport
- 35% of the national waste production
- 43% of the national energy consumption and CO₂ emission.

Sustainability will be a major criterion in judging future buildings.

Clearly, flexible buildings and installations that are adaptable to changing conditions respond to this trend.
Adaptable, recyclable and sustainable buildings will be major criteria in assessing future buildings.

Among the factors that play a role here are saving of base materials, minimizing waste production, ease of dismantling and adaptability.

Clearly, flexible buildings that are really adaptable to changing conditions respond to this trend.

Open Building provides strategies for consumer oriented and sustainable buildings, based on specific principles and methods in programming, design, production planning, construction and facility management.
Colleague Steven Kendall will tell you all the details about Open Building, as a coordinator of CIB W104: Open Building Implementation.

I will tell you here just a few basic principles.

Open Building enables built environments to adjust.

Basic idea of Open Building is the ordering of necessary decisions into different levels, from collective to individual, from Authorities to Individuals.

Authorities decide on rules and regulations in cities, regions and countries. The lower decision levels can participate or have a voice in.

The individual is responsible for decisions about his direct working or living space.
Another basic tool of Open Building is the ordering of different Plan levels, from Landuse to Infill (fit-out)

By use of levels, it is possible to fix form and space at one level while offering capacity to change and flexibility to the next lower level.

On the building level one should make a distinction between:

• Support and infill level
• Long and short life cycles
• Collective and individual decision aspects
• Supply and demand for the structural design for the building and the installations as well.
Looking into the user demands versus the market supply there are 2 possibilities.

This slide shows an example of a traditional situation.

There is a Dynamic individual user Demand for quality on the one hand, and the Supply of an average quality level on the other hand.

User 1 gets the quality level he wants.
User 2 & 4 demand more quality than supplied.
User 3 & 5 demand less quality than supplied (forced to more quality than needed).

Traditional Demand & Supply are not well tuned to each other.
This slide shows the tuning of demand and supply within a flexible Open Building strategy.
A minimum quality level is supplied on support level.
On the infill level individual user quality is added.
All users are getting the quality level they want.
User 1 on the minimum support level
The other users more than the minimum support level.

Demand & Supply are very well tuned to each other, also in the future when demands can change.
A flexible solution, with no wasted quality and costs.
The technical installations are often found to be the key factor with respect to the possibilities of adapting buildings.

Installations in particular often prove not to be sufficiently flexible to follow changes in their use without too many adaptations.

Therefore Flexibility performance indicators for installations could be regarded as a tool for assessing and discussing flexibility of a building as a whole in a rapidly changing market.

For a ready adaptation to market fluctuations it would be good to impose the condition that the building, along with its installations should be suitable for several uses. And this should be borne in mind already during the development phase.
Modularity refers to the various spatial levels at which the building or technical functions are in operation or are offered.

Within the framework of the Flexibility Indicators two major levels are distinguished:

• The local level, which is the smallest unit in a building. Every room or space in a building is composed of one or more of these units.

• The central level is the set of all the levels higher than local. In a building these are a Floor of a building (level 2), a Wing of a building (level 3) and the whole building (level 4). The highest level 5 is the urban or city level around the building.

In general it can be concluded that the flexibility of a building is determined to a considerable extent by the (spatial) level at which that particular function is offered.

For example: can heating or cooling be offered or managed per unit or per floor?

Thus, modularity is an important criterion in judging the flexibility of installations.
Flexibility Indicators (1)

This slide shows a few examples of flexibility aspects or indicators, necessary for the transformation of buildings according to the changing user demands. For instance the Rearrangement of building spaces with infill walls and movable elements. Or by making a building or components Extendible or Movable. It concerns the disconnectability of the different construction components. It also concerns the universal connection between different shaped construction components.
Removable units according to the plug & play principle

It is important that construction and installation components can be easily disconnected or removed.

The connection must allow for the removal of single components without the need to first remove or replace other components.

In other words, ensuring that changes or modifications at a lower level have no influence or effects on higher decision levels, and that they take place independently of each other.
This slide shows more examples of flexibility indicators.

For instance the expandability by the use of so called ‘open end structures’ in construction and installations as well.

Or the ejectability of building segments for different use or users.

Or the exchangeability and dismountability of construction components.

Extendibility concerns the possibility to add new building space or construction and installation components to the existing ones.

Make sure that the various levels have an overcapacity to easily adapt to an extended demand, for instance cooling or electricity.

Multifunctionality is the possibility of using building or installation systems for several functions.
One of the most important strategies to improve the flexibility of a building is to develop a partitionable structure. This means that a building (and its installation) is easy to split up into several smaller units. Or different smaller units can be combined to one bigger unit. Or different units can be rearranged. In this respect, it is important to determine both the smallest and the largest possible units. Designing and constructing with so called *fontanel constructions* is one of the possibilities to realize such a structure.
By using a structure with exchangeable partitions the structure will have more possibilities for rearranging spaces and functions.

For the fitting of a lot of different types of units within the same structure.
I distinguish 4 main Flexibility Key Performance Indicators:
Partitionable, Adaptable, Extendible and Multifunctional.
These aspects resulted from the clustering of about 20 sub-aspects of flexibility.
They can be used to describe or assess the flexibility of buildings or its components.
For a detailed description of these main indicators I like to refer you to my paper.
In order to judge the flexibility of buildings or their components, each flexibility indicator is divided into a number of sub indicators.

- **Partitionability** is judged by the parameters for Distribution (supply and removal), Conversion (central unit or supply system), Transfer (of installation functions), Measurement (consumption) and Control (use).

- **Adaptability** is judged by the Disconnectibility of the various installation components (plug-in connections), the Accessibility of components (distribution networks, zoning) and the Adjustability of measurement and control facilities.

- **Extendibility** is judged by the Capacity and Dimensions of facilities for distribution, conversion (central unit), measurement and control, and the Location and structure of distribution networks.

- **Multifunctionality** is judged by the number of Integrated functions in distribution facilities and in facilities for supply, use, measurement and control, and the extent to which the various components are universal (project-independent).
To determine the degree of partitionability, use is made of the parameters for distribution (for supply and removal), conversion, transfer, measurement and control.

This slide shows three possible ratings for each assessment aspect (3=positive, 2=neutral, 1=negative).

In addition, different weighting factors are introduced for the assessment aspects (5=very important, 2=hardly important).

Ratings multiplied by weighting factors give the partitionability scores. Thus a final judgement can be given as to the overall partitionability.

This score can be expressed as an partitionability class and can be found in the relevant table at the bottom right in this slide.
This slide shows examples of measurement and control facilities at unit and central building level.

To maximize the flexibility of a building and its installation, it is necessary to have control & measure facilities at local and central level as well.

When control & measurement is possible at the lowest individual user level, combining units to form a bigger one is no problem.

It is also easy dividing larger units into smaller ones.

When using a smart facility management system, changes in the use or function of building space cause only minor administrative changes in the computer, instead of major construction changes.
To determine the degree of adaptability, three sub aspects are used here: disconnectibility (of building components), accessibility (also components) and adjustability (measurement and control).

At the same way ratings can be given for each assessment aspect and the final score can be expressed as an adaptability class.
To determine the degree of extendibility the following subaspects are judged: the capacity (of the supply facilities, both local and central), dimensions (distribution networks) and location (ducting shafts and zones).

At the same way assessments ratings and weighting factors lead to the extendibilty score.
• Finally to determine the degree of multifunctionality the following sub aspects are judged: the number of integrated functions in components on different levels, and the extent to which the various components are universal (project-independent).

Assessment ratings and weighting factors lead to the overall multifunctionality score and class.
In the foregoing I showed you in detail the criteria used in judging the four flexibility indicators.

Also at a higher level, the overall flexibility of a building or installation can be determined.

Here, too, weighting factors, scores and flexibility classes are used. Weighting factors indicate the degree of importance of the flexibility indicators relative to each other.

The flexibility of one indicator is less important than that of another.

This form can be used both in judging existing buildings and their installations and in formulating the performance for new future buildings.

In this way we take care for both the supply and the demand side of the building market.
• For a direct comparison between different construction or installation systems we can draw a so-called flexibility profile.

• In the flexibility profile of Example 1 on the left the Partitionability score=5, the Adaptability score=3, the Extendibility score=3 and the Multifunctionality score=1.

• Together they represent the total flexibility score.

• In the flexibility profile of Example 2 on the right the Partitionability score=2, the Adaptability score=1, the Extendibility score=4 and the Multifunctionality score=5

• In this way different buildings or installation systems can be easily compared.

• In the case of Example 1 the predominant aspects of its flexibility are in the upper right-hand area of the profile.

• In Example 2 the predominant aspects are in the lower left-hand area, with emphasis on multifunctionality and extendibility.
Conclusions

• **Flexibility Key Performance Indicators** enable the communication about the flexibility of a building and its installations, on both
  • The *supply side* (assessment of existing flexibility) and the
  • The *demand side* (formulating future flexibility) of the building market as well
• **The standardized assessment form** is simple and works rapidly
• **Different clients come to different conclusions**

• With the so-called Flexibility Key Performance Indicators a detailed picture can be obtained of the flexibility demanded by the market from the one hand and the flexibility offered by the buildings on the other hand.
• This enables parties involved in the development of a building to communicate about the flexibility of that building and its installations.
• When applied in actual practice in the Netherlands, this method proved to be very useful.
• Using the standardized assessment form, flexibility can be judged simply and rapidly.
• At the same time it is clear that the assessment of flexibility very much depends on personal or corporate views.
• Different clients judging the same building will come to different conclusions.
Minds are like parachutes.
They work best when they are open.

Ladies and gentlemen, that concludes my presentation.

Thank you very much for your attention!