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Data centers in commercial office buildings (Part I)

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Not every office building is fit for data center loads. Here's how to determine if it is

7 April 2011 by Marco Shmerykowsky

Part I of a two-part article

More and more companies are relying on third party colocation centers for data storage, but many New York firms still prefer to keep servers and other network essentials on site. However, most commercial office buildings are simply not designed to support the concentrated loads superimposed by server and data storage racks.

While a typical colocation center is designed to support loads of up to 150 psf, load capacity for office space is typically defined by the building code as 50 psf. A structural evaluation by a licensed professional engineer (P.E.) is therefore imperative to ensure the adequacy of the structure in question.

The engineer will perform the following tasks: determine load-bearing capacity of the structural members that will support the data center, ascertain what reinforcement will be necessary and develop the most efficient means of structural support, depending on arrangement of the existing structural system.

At the beginning of the design process, the structural engineer will request a set of specifications describing dimensions and weight of the equipment to be installed. The engineer will then consult the building's Certificate of Occupancy or loading schedule to determine load capacity.

If the superimposed load due to the new data center equipment is smaller than load capacity listed on building's Certificate of Occupancy, then the engineer can approve the installation without a great deal of further scrutiny. This is, however, a rare occurrence.

When equipment load is higher than the building's certified load
After evaluating specifications for the new data center equipment and consulting the building's Certificate of

Occupancy, the engineer will review the building's structural drawings. It is of paramount importance that the building's original construction documents, including structural drawings, be retained by the property management team.

Keeping these documents on hand can be the difference between one site visit by the structural engineer to verify existing conditions and multiple site visits to determine the existing conditions, a process that can include necessarily destructive testing procedures and, in any case, will increase the project's overall cost.

The cost of misplaced construction documents

If the building's original construction documents are not available, the structural engineer, with the aid of construction professionals contracted by the building owner, will determine the existing site conditions. To determine dimensions and other properties of a concrete-encased steel beam, for instance, contractors must strip away a portion of the concrete encasement so the structural engineer can determine the depth between the beam's flanges, flange width and yield strength of the steel.

Determining the type and properties of floor construction involves further intrusive procedures. Contractors must extract a core sample from the slab to determine the slab's thickness. The structural engineer will then determine through a visual inspection whether the slab is made of gritcrete (also known as cindercrete) or contemporary standard concrete.

The distinction is important because the strengths of the two materials are different. Gritcrete slabs can be found in buildings constructed before the 1960s, after which time the material was replaced by contemporary standard concrete. Contemporary concrete can be distinguished from gritcrete by its aggregate content – the latter is mixed with stone aggregate, while the former is mixed with cinders.

The engineer will also examine the slab from below to determine the thickness and type of the metal deck.

Most such testing – and its costs – can be avoided by preserving the building's original construction documents, including structural drawings. Once the engineer has received a copy of the building's structural drawings, or determined the dimensions, properties and types of structural members through on-site testing, he or she can ascertain whether the existing structure can support new data center equipment as is or whether it will require reinforcement.

End of Part I. In Part II [8], Shmerykowsky describes the structure-analysis process for office buildings and ways structural components can be reinforced to adequately support data center equipment. Click here to read Part II. [8]

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12 April 2011 by Marco Shmerykowsky

Part II of a two-part article. Click here to read Part I [8]

Structure analysis
Analysis of the building structure is based on the concept of tracing the path a superimposed load will take as it flows from the point of application toward the building foundation. Further, the objective will be to investigate the structure for the actual arrangement of objects as opposed to a layout, which may vary in the future.

Analysis of the slab
First, the structural engineer will investigate the slab construction. The slab can be viewed as a shallow beam which is one foot in width and spans between supporting beams.

The engineer will determine whether the slab has adequate capacity to support the new loads in bending as the slab spans between supports. Additionally, the engineer will verify that the slab has adequate shear capacity.

If the slab requires structural reinforcement, several options can be entertained. A large steel plate may be placed on top of the floor to spread the load over a larger area; steel beams may be added beneath the floor to support the slab; steel beams may also be added above the floor slabs which will span to acceptable support locations.

The type of reinforcement will depend on various practical and technical constraints.

Analysis of the steel beams
Once slab capacity is verified, the structural engineer will check the steel beams that support it.

In addition to considering load from new equipment, the engineer must consider the surrounding loads the beam must carry. This includes the weight of hung mechanical equipment and hung finished ceiling in the tenant space below the floor being investigated, the weight of partitions, the weight of floor finish and/or raised floor and any other equipment in the surrounding area.

It will also be necessary to include a load allowance.

In a data center, the space not occupied by equipment will most likely be empty aisle space, only subject to the occasional superimposed load of an IT technician. As a result, the engineer may use his or her professional judgment to select a load for the balance of the space that is lower than the original design load. This will lead to a more realistic load distribution that more closely reflects the actual loading of the structure's adapted use.

If a beam requires reinforcement, the engineer will either add beams to help carry the load or weld an additional section onto the existing beam to improve its load-carrying capacity. Both of these options require that the space below the floor is accessible and free of obstructions from architectural details, mechanical pipes, HVAC ducts, et al.

If it is not feasible to work from below the floor level, the solution becomes much more complicated and more expensive.

A structural engineer can perform reinforcement work from above the slab by essentially routing superimposed load from the new equipment to the floor above. This entails engineering a structural platform which is then hung from the floor above. Additionally, the floor above will likely require some version of “below-the-floor” described above.

Connection of the beam and its supporting member
The next point in load path is the connection between the beam and its supporting member, whether it's a girder or a column.

Typically, buildings are designed with connections that have a slightly larger capacity than required by the original design loads. This additional capacity accommodates minor changes in the building's loading. Nevertheless, large increases in connection forces will require reinforcing the connection.

In case of a steel connection, this is typically accomplished through additional welding. If the required capacity is more than welding can acoomodate, the engineer may need to create a connection that incorporates existing and new connection material.

The last two items that will typically be reviewed in load path are capacity of the girder supporting floor beams and connection of the girder to the supporting column. At both of these points, the structural engineer will perform similar checks to the ones described above.

Installing an on-site data center in a commercial office building is not simply a matter of loading server or data storage racks into available space. A proper structural investigation is essential in ensuring that these unique load sources are properly supported and in maintaining integrity of the overall structure.

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