Technical Brief

Fully composite walls for data centers

We have found that the use of C-GRID FRP truss reinforcement in the design of fully composite walls leads to thinner overall walls, less material, greater economy, and superior performance.

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Precaster: Metromont Corporation

Data center buildings provide an excellent application for insulated precast concrete wall panels. To evaluate wall designs for comparison of competing systems, however, it is important to consider how data center construction may be different from other commercial construction that uses insulated walls. The characteristics of data centers include high floor loads and requirements for high security and high resiliency from environmental loads. There may even be a need to provide resistance to blast.

continued

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Important considerations

Building structure and configuration. Most of the original data centers from 20+ years ago were one-story buildings. Some were total precast, with precast concrete roof framing carrying heavy equipment loads and resisting extraordinary lateral forces. Others were steel-framed buildings that used the insulated walls only for strong environmental enclosure, and as part of the lateral force-resisting system. Over time, with the value of land and the increased efficiency of lower surface-to-volume ratios, these structures have evolved to two-story or more buildings. In some of these structures the uninterruptable power is provided by interior generators mounted on mezzanines. In some cases the generators and battery back-up are ground-based in exterior courtyards. These exterior installations usually require wall openings for cable runs, cable trays and piping.

Weather resilience. Because data centers are often mission-critical, they are assigned to Risk Category III or IV. The higher risk classification adds safety factors for many aspects of design, but in some cases additional factors are added for higher than code-mandated loading. For wind loading, category III or IV assign wind maps with higher wind speeds, but these are still considered conventional loading. We have had owners ask for the wind speed to be increased to the level where the weight of the precast concrete roof framing is just sufficient to prevent overcoming the uplift suction. That wind speed is around 160 mph. We have had other cases in vulnerable regions where wind speeds of 200 mph to 250 mph are specified to provide tornado resistance. The wind uplift on these buildings can require cast concrete as ballast over the insulation and roofing. When these high wind speeds are considered, the design of the walls must take the increased lateral forces, both for out-of-plane flexure and for in-plane resistance as shear walls in the lateral force-resisting system. The wind load is often more severe due to tall parapets that screen rooftop equipment.

Seismic resilience. When the risk category is increased, there are also effects on the design for earthquakes. The level of risk for earthquake design is characterized by seismic design category (SDC). The assignment to SDC not only affects the lateral forces by added safety factors, but also the detailing for ductility and resiliency by prescriptive requirements in the concrete code. When a structure is assigned to Risk Category IV, SDC B (low risk) becomes SDC C (moderate risk) and SDC C becomes SDC D (high risk). This upgrade can have profound implications for design.

Gravity loads. Gravity loads in data centers can be quite high. Even for one-story structures, mounting generators on mezzanine floors is not uncommon. Chillers and air-handling equipment are often added to the roof. There is also the weight of hanging loads of electrical raceways and piping. Although much of this load is carried by the interior framing of the building, exterior walls often are designed as loadbearing for the economy of eliminating independent perimeter framing. The electrical trays and cooling piping are often mounted to the walls with brackets that hang the loads away from the wall face. When the buildings include a second floor, the live load for computer equipment can be 250 psf to 300 psf, with additional dead loads for electrical pathways or other superimposed dead loads. We have designs in

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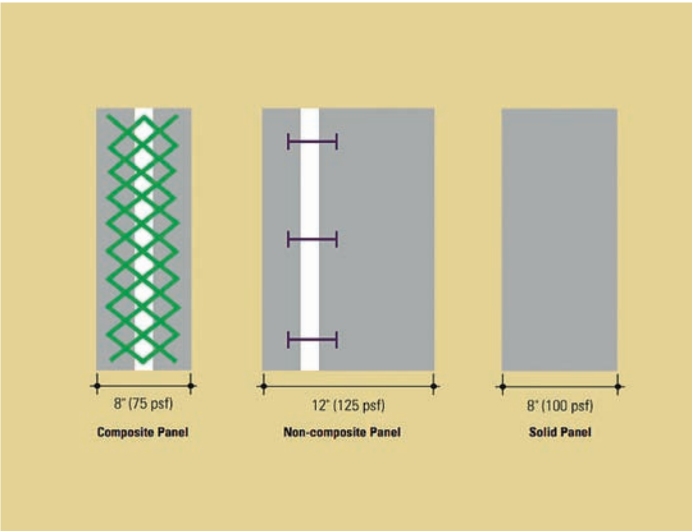

total precast buildings that include deep, heavy double tees with added cast-in-place concrete topping that can develop 60,000 to 75,000 lbs. per stem reaction. When the roof is also precast concrete with topping and superimposed equipment loads, the walls must carry two levels of reactions to the ground.

Non-composite and partially composite insulated wall panels

There are two basic approaches to the design of insulated flat slab wall panels, but both are intended to develop continuous insulation between the concrete wythes to meet stringent energy requirements that have developed in the building codes.

The first approach is non-composite walls. For this design, there is one dominant structural wythe that is thick enough acting on its own to provide the strength and stability to carry the gravity, out-of-plane and in-plane loads imposed on the wall. The other wythe is usually thinner and mostly provides protection for the insulation from the exterior environment. Some designers may consider a small contribution of the non-structural wythe in resisting out-of-plane forces based on the relative stiffness of the two wythes. These panels are typically thicker walls with more concrete because only one is relied upon for the strength of the wall. The most common approach uses discrete pins placed uniformly across the insulation. The pins are designed only to hold the non-structural wythe to the structural wythe.

They are commonly made from fiberglass, molded plastic, and/or carbon or basalt FRP composite materials. A different wythe shear connector can be used to carry shear load across the insulation for partially composite behavior.

Proprietary software to evaluate connectors required to evaluate the performance of the shear connector is commonly employed. This evaluation will not only check the shear strength but also recommend a connector layout for the wall panel being designed. The user should require an engineering seal for the drawings to validate the basis of the calculations and methodology employed. The software shows that typical layouts return values between 40% and 60% composite. We also find that the percent composite varies along the height of the wall depending on the amount of "wythe slip" or shear displacement between the concrete wythes. Suppliers' engineers we have spoken to have not been encouraging in applying their composite systems to high-load data center walls.

Figure 1 shows a simple pin layout and insulation cut drawing for a basic wall panel.

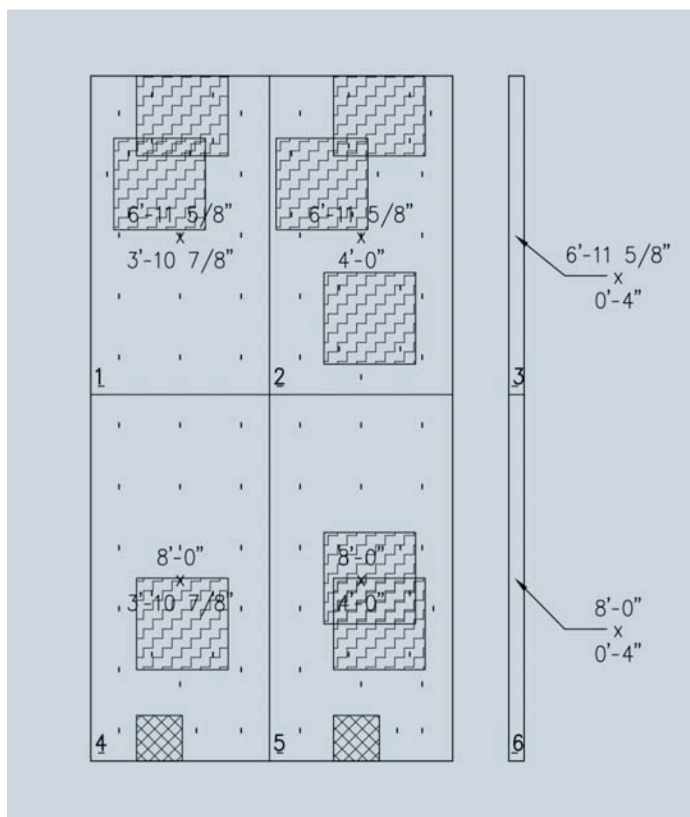

Figure 1

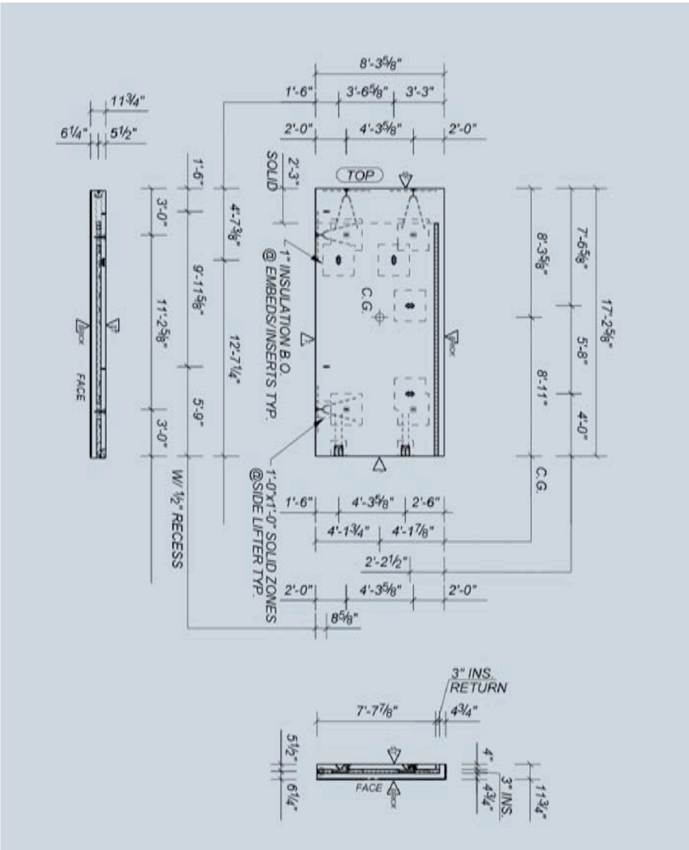

Figure 2

This is the approach used for CarbonCast® walls that use C-GRID® high-strength carbon fiber grid as the shear connection. Even though the design of the C-GRID is based on the distribution of the shear predicted by flexural mechanics of the wall (VQ/I), it is recognized that the foam layer with the C-GRID is not as rigid as solid concrete. For this reason, the design of CarbonCast walls achieves about 90% composite behavior, which is considered in the overall performance of the wall.

In data center construction the thickness of the concrete wythes on non-loadbearing wall elevations is often equal and less thick than the loadbearing walls, although that can vary for convenience of casting. The wall thickness generally depends on the wall spans or floor-to-floor height.

Figure 3 shows a partial elevation of a non-loadbearing wall where panel thickness was not varied from loadbearing.

Figure 2 shows the basic shop ticket for the panel as part of the fabrication set. (There are also reinforcement tickets and finish tickets used by the manufacturer.)

Composite wall panel approach

The second approach to insulated wall design is the composite wall approach. Composite walls use the two concrete wythes together with shear connection across the insulation wythe that has the strength and stiffness to cause the wythes to act together as a wall of the total thickness.

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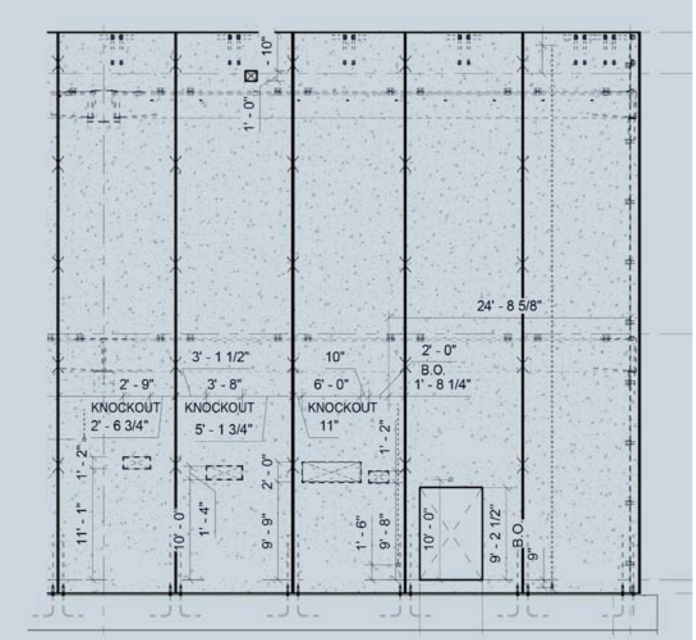

Figure 3 Partial elevation of non-loadbearng wall (56–10½" tall)

Parts of a shop ticket for one of these panels are shown in Figures 4, 5 and 6.

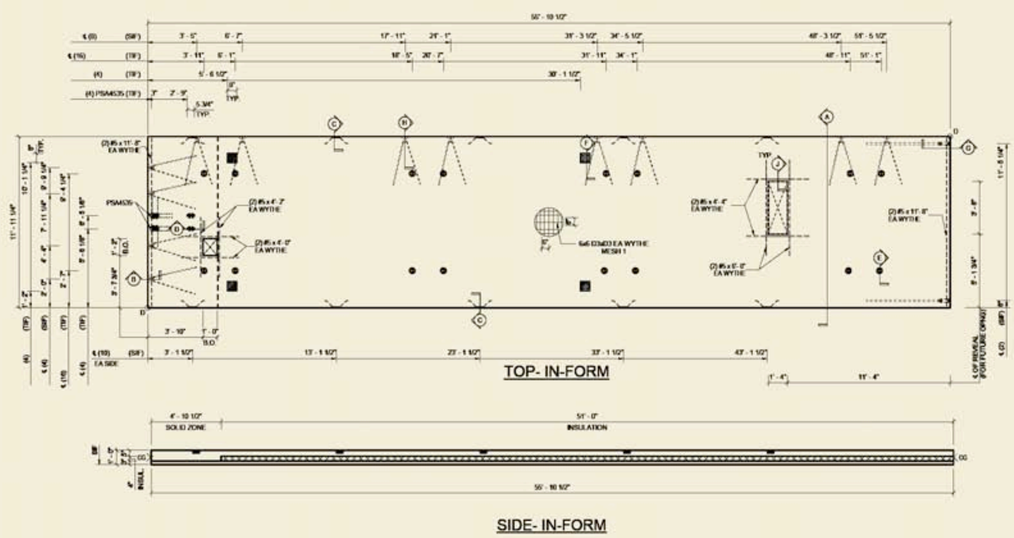

Figure 4 Plan view in ticket

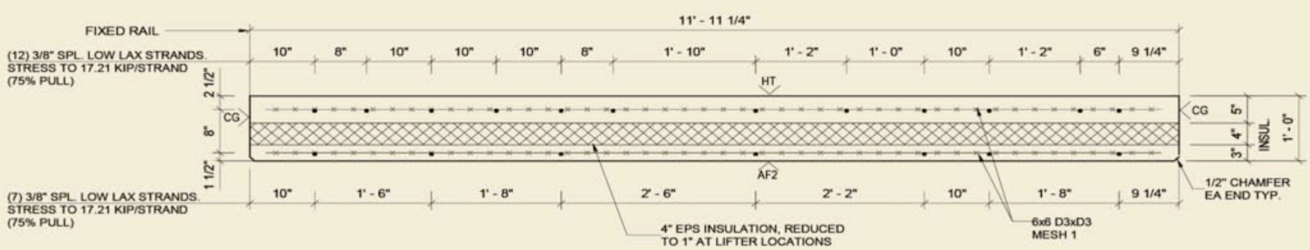

Figure 5 Wall section

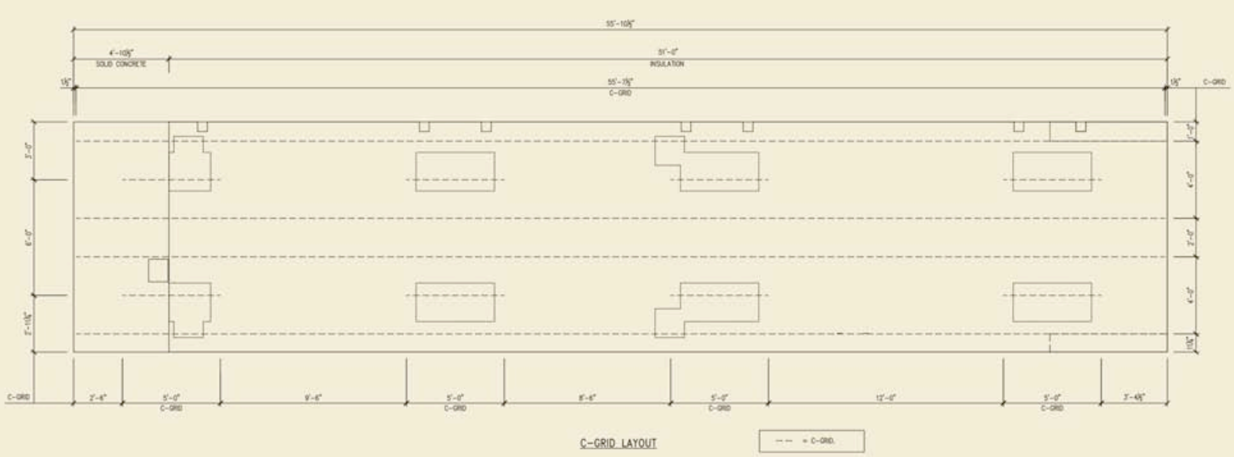

Figure 6 C-GRID layout

Fully composite walls for data centers *continued*

Figure 7 shows a partial elevation of a loadbearing side with the floor double tees and roof double tees on the far side of the wall for a total precast structure. This elevation is the same height as the other, but because the panels are loadbearing and thicker, they are split with a horizontal joint above the floor level. The different connections in the vertical joints indcate how the walls are grouped together as shear walls in the lateral force-resisting system.

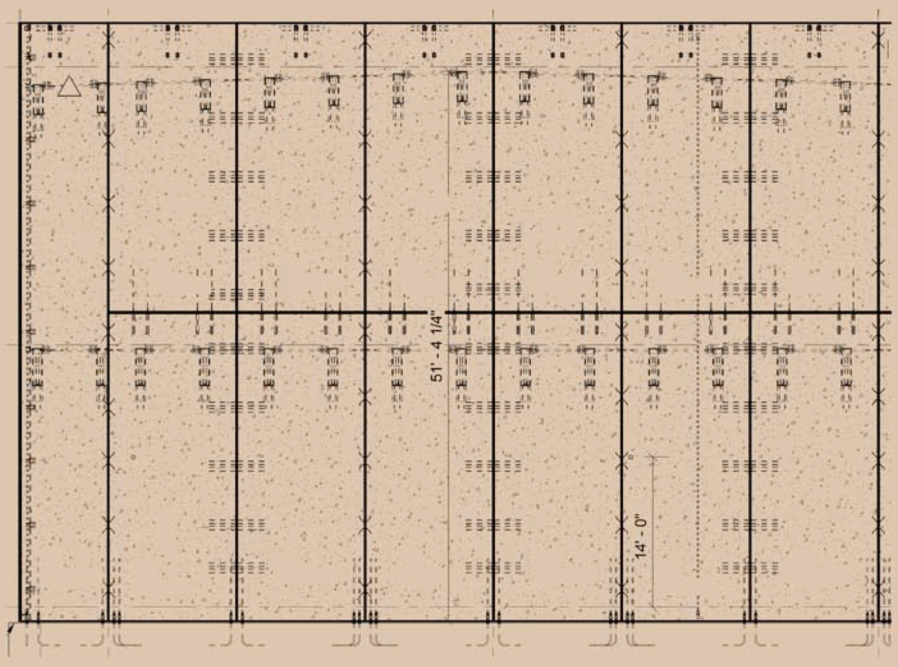

Figure 7 Partial elevation of loadbearing walls

To reduce the eccentricity of the loads on the wall, the double tees bear into pockets. With the heavy load, however, the 5" interior wythe thickness was not sufficient for bearing stress. A short projection was made to the interior of the building and the insulation thickness was reduced within the wall to lengthen the bearing. A detail of this bearing is shown in Figure 8. A plan view of the ticket is shown in Figure 9. The C-GRID layout is shown in Figure 10.

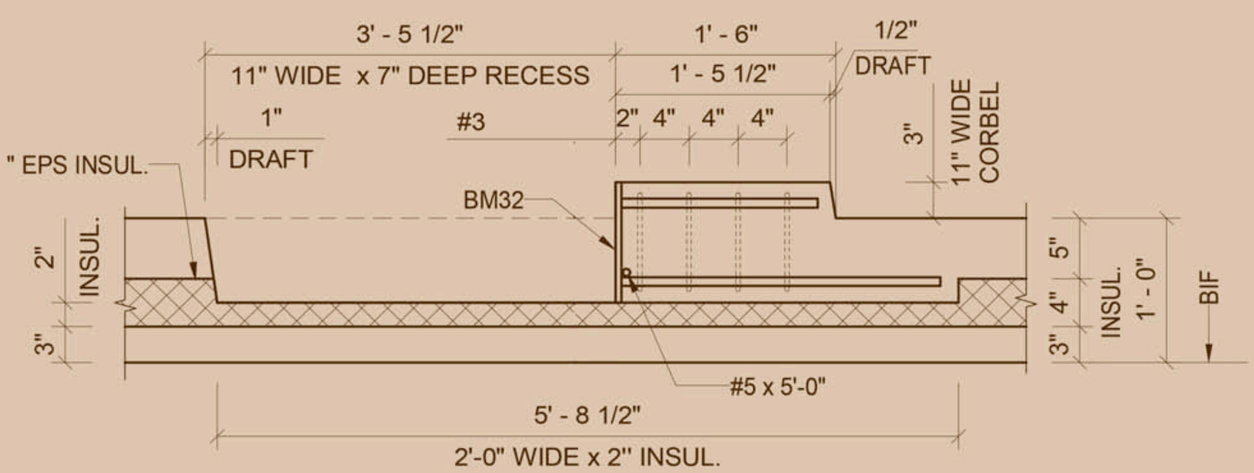

Figure 8 Bearing enlargement section

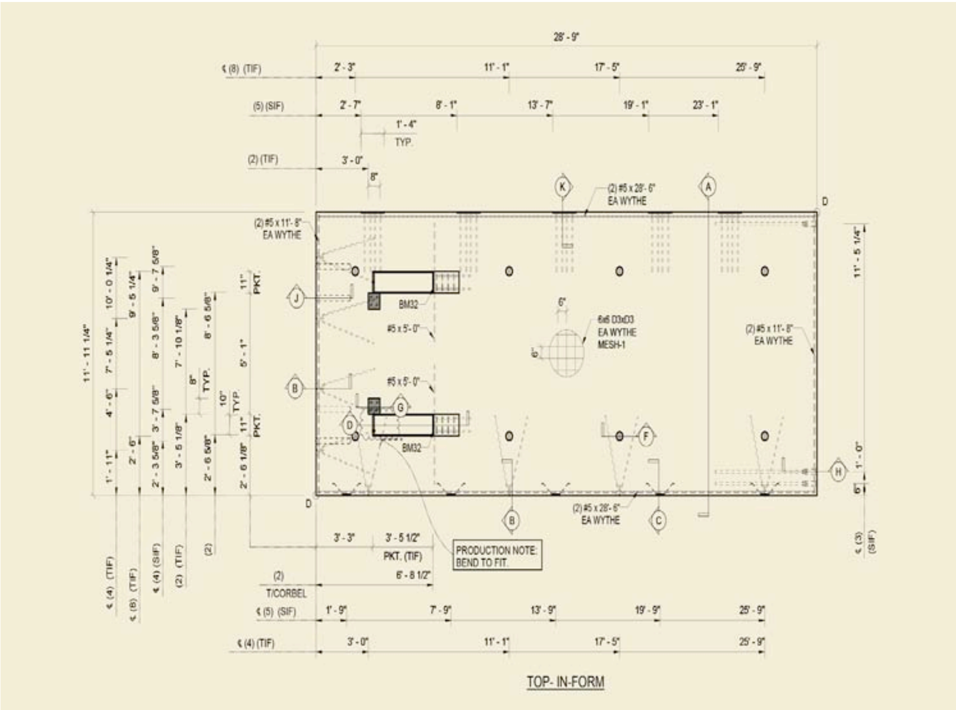

Figure 9 Plan view of ticket

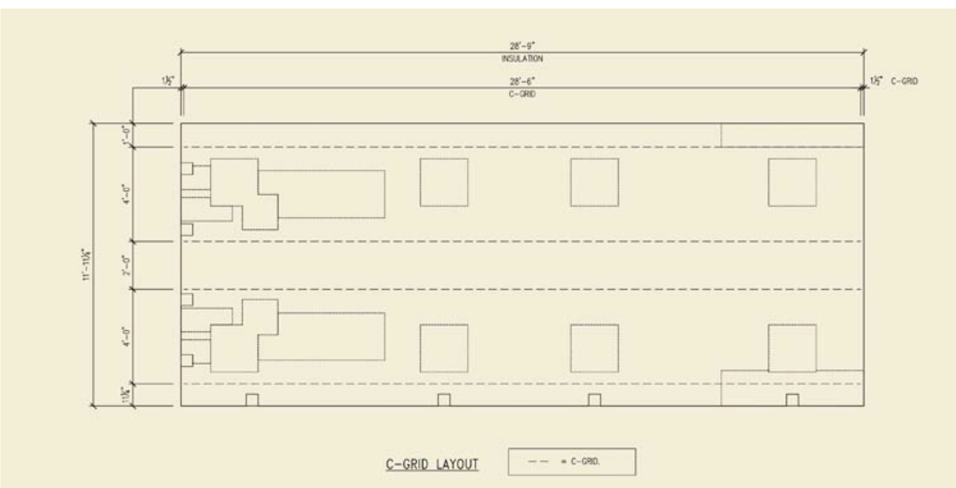

Figure 10 C-GRID layout for loadbearing wall

There are so many variations in the criteria and layouts in data center buildings that it is hard to illustrate the many different comparative solutions between non-composite, partially composite and composite systems. We have found that the use of C-GRID FRP truss reinforcement in the design of fully composite walls leads to thinner overall walls, less material, greater economy, and superior performance.

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For more information, go to **altusprecast.com** and learn how CarbonCast® can deliver resilience for your project as well as lasting performance that generate positive ROI. Call us today to speak with a technical representative or request a lunch-and-learn program.