Vibration Isolation and Seismic Control
Manufacturer's Association
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Wind Restraint of Roof Mounted Ductwork

On the rare occasions that a mechanical engineer asks for advice on roof-mounted ductwork during the design phase the first piece of advice might be; don't do it. Just don't put the ductwork on the roof. Duct is relatively lightweight with a large face area, especially on main duct lines coming off rooftop equipment. It makes an excellent sail and ideally duct should never be mounted on the roof in wind-prone regions.

If duct must be mounted on the roof it is best to advise engineers to keep a low profile and tight to the roof structure. While the latest versions of the code may have a vertical wind component, the main force is still horizontal; keeping the duct short and wide will reduce the total horizontal force that must be restrained. Keeping a low profile reduces the prying action, and additional tension anchors will experience for duct supports that do not have external bracing. Also, round duct provides a significant reduction in wind load due to the shape factor.

Unfortunately, the reality of the situation is that mechanical engineers rarely consider the sizeable horizontal wind loads roof-mounted duct will experience, and often they like to detail tall stands to allow maintenance workers to walk below the ductwork instead of providing stairs and walkways over duct for access. Contract details are often inadequate when provided. Engineers have called for free-standing strut stands that would never be capable of transferring the wind loads to the structure without failure, have called for tall unbraced stands that would see thousands of pounds of tensile load on the anchors detailed with an 18 gauge sheet metal footplate. One frustrated mechanical engineer wanted to run cable vertically down the leg of the stand and attach to the curb the stand was sitting on because he did not want to penetrate the roof for an external brace.

This often leads to situations in which the installing contractor who won the bid did not carry nearly enough money to cover the material and engineering costs required to adequately brace the ductwork. The best advice to give to an engineer is no matter how you plan to address the restraint of roof-mounted duct, make sure that it is adequately detailed on the contract drawings and specifications. If not, the result will be a situation where everyone is pointing fingers at everyone else and no one feels they should be responsible for the costs they did not carry going into the project.

Say you have a customer who approaches you with a project that has several large duct runs on the roof and the contract drawings have delegated responsibility for the engineered design to the installing contractor. As is typical the BOD of the duct is six feet off the roof deck for most locations. How do you restrain the duct to meet wind code? There are two typical methods, each with its own advantages and disadvantages: external bracing can be provided to selected stands or all stands in the duct run can be positively attached to the structure.

External Bracing:

External solid-arm or cable braces can be installed at the beginning and end of the duct runs, on both sides of any 90 degree turns, and at intermediary stand locations in straight runs with spacing determined by the wind load per foot and duct size/construction. External braces have the advantage of fewer roof penetrations, as the stands do not require positive attachment to the roof deck and the stand construction can be lighter since a correctly installed external brace will eliminate most or all of the bending stress in the stand. The disadvantage of external anchors is the much larger load on the structure which may restrict the location of the brace anchor to main structural steel beams or require supplemental structural steel installed below the roof deck to transfer the load from the anchor location to the main force resisting structural elements.

Most roof decks have a layer of insulation of varying thickness and a roof membrane. Installing a brace from the mid-point of the duct elevation directly to the roof structure at a 45 degree angle is impractical, as the brace would need to penetrate the roof membrane at an angle and no roofing contractor will warranty that kind of installation against leaks. As a result, roof anchors often must be used to make the final attachment to the structure and this can increase the costs associated with the external anchors. The roof anchor must be tall enough to extend beyond the roof membrane level, must be strong enough to accept the bending stress developed from the loads on the top of the anchor, and must be made from standard structural steel pipe or tube steel that has off-the-shelf rubber flashing for integration into the roof membrane.

Positively Attach All Stands:

Positively attaching all stands in the duct run to the structure has the disadvantage of more roof penetrations; however, it has the advantage of significantly reducing the load seen by the structure at any given location. Typically, post-installed concrete anchors can be used to secure the stand and no special consideration or supplemental reinforcement of the structure is required.

As with external bracing, there is usually still insulation and weatherproofing to contend with. A common configuration is a concrete roof deck covered with insulation and topped with a roofing membrane. The stands can be designed for easy flashing into the roof membrane, or supplemental flashable rails can be used to support the stands.

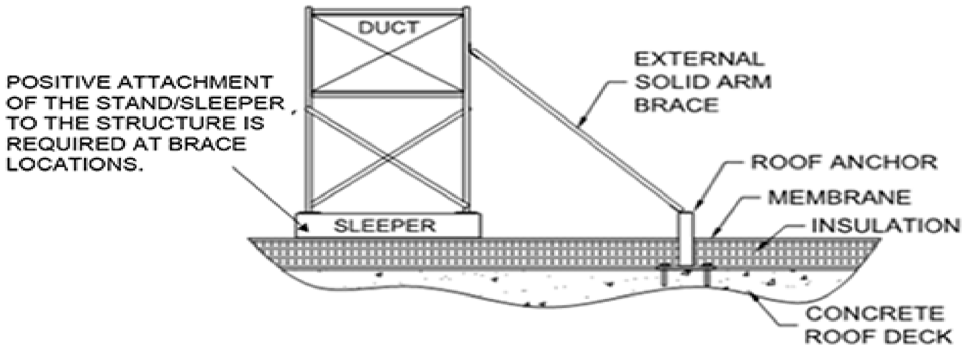

FIGURE 1: Typical Externally Braced Stand

If flashable rails are used, they must be rated for horizontal and uplift tension loading and they must have the capacity to allow the stand to be welded or bolted to the top of the rail (sorry, but lag screws in a 2x4 typically are not going to suffice). The stand can be designed with full cross-bracing between the legs top to bottom to eliminate tension due to prying action, and the rails will only see shear loads and any tension due to overturning.

When stands are to be attached directly to the concrete roof deck, the stand legs should be made from standard structural steel pipe or tube steel. As noted for external roof anchors, these shapes have off-the-shelf rubber boots and can be easily flashed into the roof membrane. Prying action can become an issue with stands connected directly to the roof deck covered with insulation. Cross bracing between the legs of the stand must be kept above the roof membrane level to prevent problems with weatherproofing. Even a 12" to 16" free-standing section of leg can generate tens of thousands of inch pounds of moment on the stand foot and thousands of pounds of force on the anchors (in addition to the shear load and tension due to overturning of the stand). If the insulation is thick enough, horizontal members may be used below the roof deck tying the legs of the stand together with a moment-resisting connection to eliminate or at least largely reduce the prying action forces.

<u>Conclusion:</u>

Regardless of how you restrain the ductwork, the mechanical engineer of record for the project must be made aware of the potential problems with restraining roof-mounted duct against wind loads and the various methods available to solve those problems before the project comes out to bid. Adequately detailed contract drawings and a clearly defined specification will allow the bidding contractors to carry an accurate cost for the installation, and this will eliminate 99% of the problems encountered in duct restraint no matter what method is used.

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VISCMA is a non-profit association representing the manufacturers of seismic restraint, vibration isolation and noise control equipment. The primary objectives of the organization are to educate the construction industry on the proper use and application of vibration isolation and seismic restraint and to develop standards to continually improve the industry.

In partnership with FEMA and ASCE, VISCMA also publishes three Seismic Installation and Inspection Manuals designed to assist field personnel.

The association office is located at 994 Old Eagle School Road, Suite 1019, Wayne, PA 19087-1866 and can be reached at 610-971-4850 or info@viscma.com.