ASTM STP 996 : The steel/silicon diaphragm system

구조용 Silicon Selante 및 mechanical fastner를 이용한 Rain Screen 과 Equalization(등압)의 설계

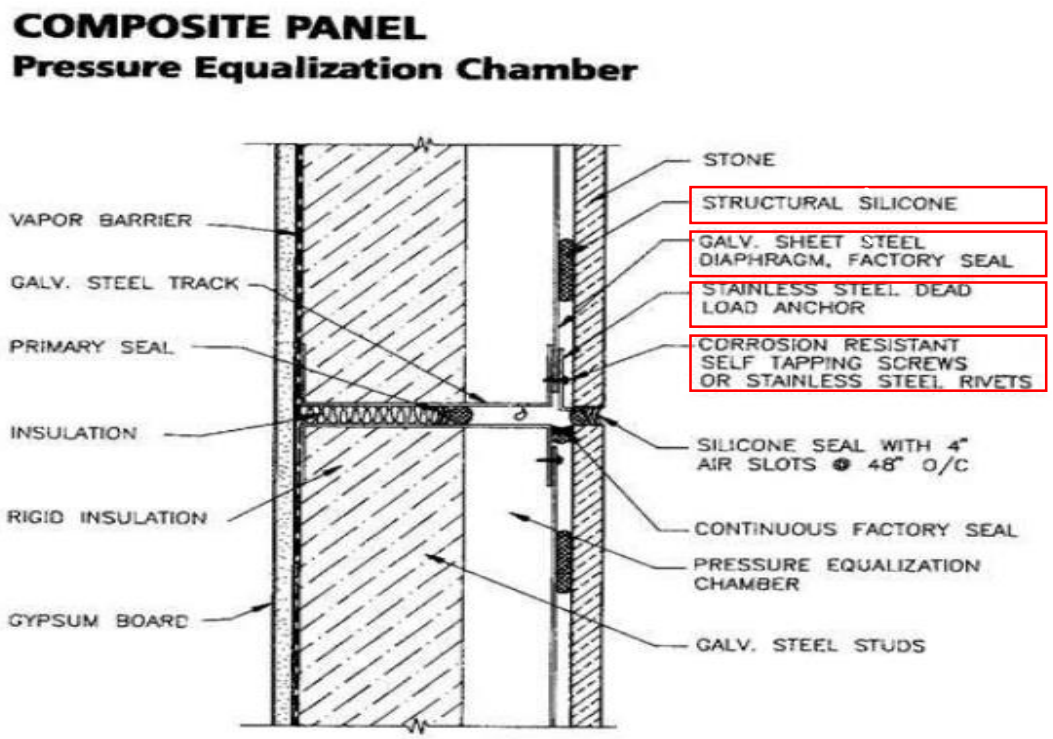

Figure Example of a rain screen design.

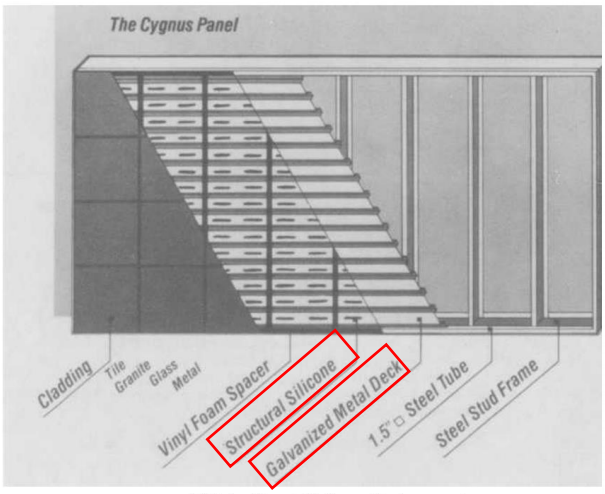

FIG. 1—*The steel/silicone diaphragm system.*

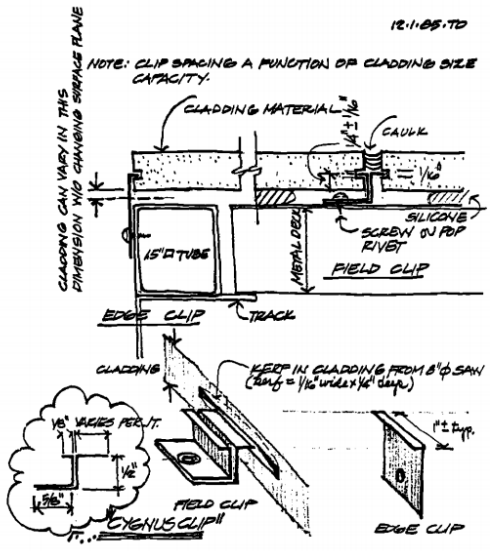

FIG. 2—*Cygnus mechanical fastener leveling device.*

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Hybrid Panel System은 Structural Silcone Sealant의 개발에 의해 고안된 Hybrid Sealant Adhesion system으로 내부의 구조에 Rain Scren(Gal.metal deck 차수막)을 설치하고 Air vent(통기관) 및 배수관(Weping hole)을 1.2m (48in) 간격으로 길이10mm 의 slots weping hole을 설치하여 Weather seal의 손상에 의해 외부로 부터 유입된 우수를 차단된 등압공간에서의 중력에 의해 다시 외부로 배수하도록 설계된 것이다.

"Such a composite connection system utilizes the mechanical fasteners for dead loads and the silicone for dynamic wind loading in a manner similar to the now familiar structural glazing phenomenon. " (첨부 자료 p 140 참조)

" 이러한 복합 연결 시스템에서는 고정하중은 기계식 패스너를 사용하고 동적 풍 하중 에는 실리콘을 사용합니다."

William Loper[1] *and Thomas Obermeier*[2]

Thin Stone Veneers—A Steel/Silicone Diaphragm System

REFERENCE: Loper, W. and Obermeier, T., **"Thin Stone Veneers—A Steel/Silicone Diaphragm System,"** *New Stone Technology, Design, and Construction for Exterior Wall Systems, ASTM STP 996,* B. Donaldson, Ed., American Society for Testing and Materials, Philadelphia, 1988, pp. 137–140.

ABSTRACT: Stone utilization and fabrication has evolved rapidly in recent years. Originally, stone was a massive structural building material. Today, with the use of sophisticated cutting techniques, stone can be a thin veneer cladding for building exteriors. To utilize this thin stone product a number of prefabricated panel systems have appeared including the Cygnus steel/silicone diaphragm system. The Cygnus system utilizes structural silicone to uniformly distribute the exterior dead and dynamic loads over a galvanized steel diaphragm panel. This patented, proprietary manufactured system provides a tough, durable, light-weight exterior skin utilizing stone, tile, aluminum, or glass exterior cladding material.

KEY WORDS: steel/silicone diaphragm, cygnus panel system, thin veneers

Stone as a building material originally was utilized primarily on bearing wall or post and lintel construction. The Parthenon, Stonehenge, and H. H. Richardson's Marshall Field warehouse in Chicago are fine historical testimonies to this building technique, that is, stone used as a massive, substantial, and worthy material.

In the mid-nineteenth century, building techniques for tall structures evolved. The Brooklyn Bridge, the Eiffel Tower, the Crystal Palace, and in stone Louis Sullivan's ten-story Wainwright building in St. Louis utilized structural metal frames; concrete frames for tall structures were soon to follow. Stone, the massive, substantial worthy material, was no longer holding the building up, but more modestly holding the weather out. This worthy material's function had changed. It had no need of thickness; in fact, thickness was a liability for a material whose function was to curtain the interior from the exterior. The now thinner exterior skin had the obvious advantage of providing more usable space within the building and required the structure to support less weight. The concrete or steel frame did the structural work; the stone was relegated to the role of cosmetic skin. Architects and designers have struggled with the aesthetic expression of this new thin stone cladding.

Subsequently, stone fabrication evolved again. With this evolution came more sophisticated saws providing better cutting technique and greater dimensional control. Sizeable pieces of stone are now available 1-cm thick. For exteriors, the once traditional 7-cm-thick stone weighed 180 kg/m^2. The now available 1 and 2-cm materials weigh 25.6 and 51.2 kg/m^2, respectively. This now thin but still worthy, exciting material has two attendant problems, how best to express it aesthetically and how to hang it functionally.

The first of these problems is basically beyond the scope of this paper except to report

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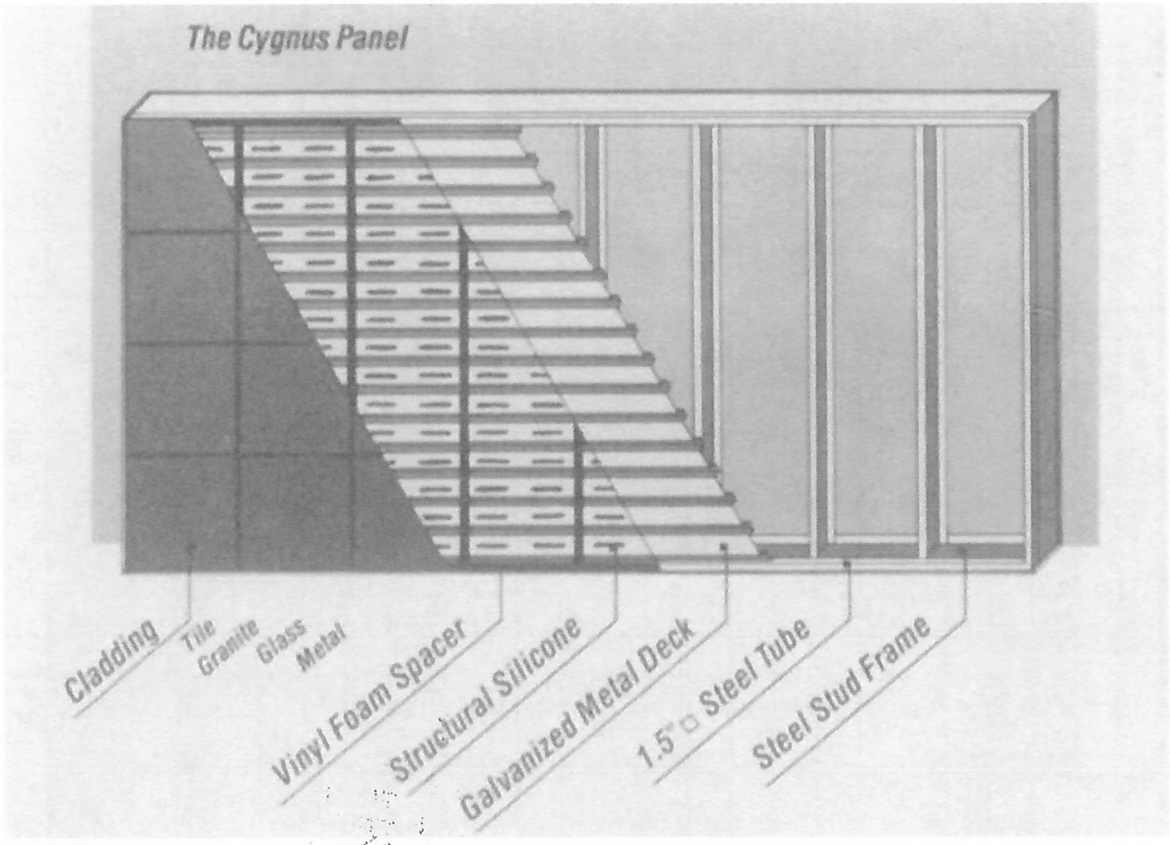

FIG. 1—*The steel/silicone diaphragm system.*

that the tools for solving this aesthetic dilemma would appear to be color, texture, and pattern as opposed to the expression of thickness. The stone can be fabricated in various finishes, honed, flamed, polished, and others, and can be arranged in patterns and designs combining color and texture. Architects, designers, and building owners increasingly recognize inherent economic and problem-free advantages of flush exterior skins and rely on color, texture, and pattern to enrich their design. The now thin but still worthy stone works well in these patterned, substantially flush, curtain wall systems.

To solve the market's impulse to utilize this thin stone product, we find a proliferation of panel systems. These systems include:

1. Precast concrete.
2. Glass fiber reinforced concrete (GFRC).
3. Truss or strongback (considered conventional).
4. Stucco and backer board.
5. Steel/silicone diaphragm.

Consideration of these industrialized factory-manufactured systems should include the following:

1. Weight and thickness of skin.
2. Structural connections.
3. Structural loads (dynamic and static).
4. Panel shape and design potential.
5. Thermal expansion and contraction.

6. Seismic loading.
7. Water and/or air penetration.
8. Durability of components.
9. Single source building skin responsibility.
10. Safety factors.
11. Building code considerations.
12. Quality assurance.

The steel/silicone diaphragm system, in production since 1981 with over 75 structures completed or in progress, addresses the above considerations in a unique manner. The system (see Fig. 1) is composed of a nonload-bearing, steel stud frame to which 22-gauge 3.81-cm hot dipped galvanized steel decking is screw attached. Frost-proof cladding (ceramic tile, granite, limestone, or marble suitable for exterior cladding) is spaced 0.3175 cm from the decking with vinyl foam tape and attached to the galvanized decking with structural silicone, a material that can accommodate 50% movement while carrying tensile loads of 1.36 kg/cm^2 (20 psi), including a 4 to 1 safety factor. The silicone distributes the loads on the cladding in a uniform pattern, thus avoiding point loads and concentrated stress conditions. The structural silicone is applied in quantities so the unit shear stress does not exceed 0.068 kg/cm^2 (1 psi). A mechanical fastener (see Fig. 2) designed according to Uniform

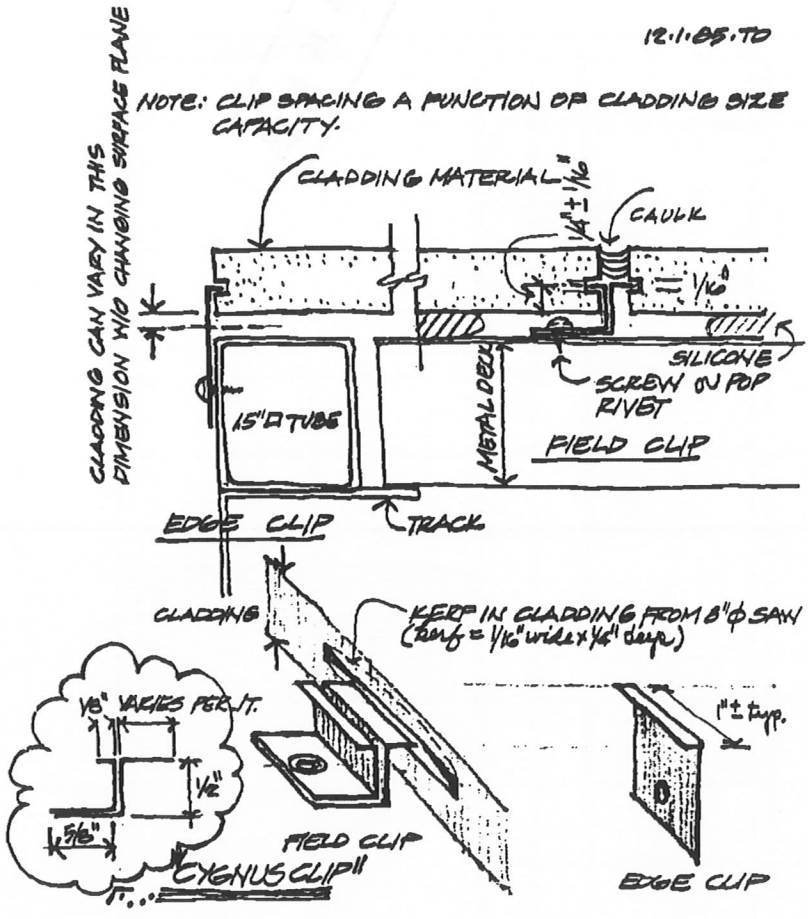

FIG. 2—*Cygnus mechanical fastener leveling device.*

Building Code requirements may be used in conjunction with the silicone if a second, load-carrying system is desired or if the weight of the stone makes the handling of shear stresses by the silicone a less economic use of the material. Such a composite connection system utilizes the mechanical fasteners for dead loads and the silicone for dynamic wind loading in a manner similar to the now familiar structural glazing phenomenon. The mechanical fastener may also aid in leveling the exterior face of the selected cladding. Once the cladding is adhered to the panel, the joints in the cladding material are factory caulked with the same structural silicone.

The galvanized steel substrate may be designed and installed to function as a secondary water barrier if the integrity of the cladding with reference to water permeability is in question.

The components when assembled combine frost-proof cladding, galvanized steel, and structural silicone to form a very tough durable diaphragm panel. This panel adjusts easily to a building's concrete or steel frame. Its integral light weight and resiliency handle wind, thermal, seismic, and appropriate structural loading nicely.

A word of caution. The thin stone veneers must be appropriate as cladding. A battery of ASTM tests for compressive strength, modulus of rupture, absorption, density, and abrasion resistance exist as standards. Information is also available regarding physical properties such as thermal expansion, modulus of elasticity, shear strength, and tensile strength. Freeze/thaw durability, water permeability, and cladding consistency are also considerations. Once an appropriate cladding is selected, the steel/silicone diaphragm system will insure a first class panel and exterior skin.

The steel/silicone diaphragm is a patented, proprietary system, thus assuring its availability from qualified, professional sources.