

Felt Tips

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In keeping with CSI's purposes and objectives we present a paper originally presented in the February 1992 edition of The Masonry Society Journal. Clayford T. Grimm has written articles on masonry which have appeared in numerous publications. Mr. Grimm's opinions are sometimes controversial. The Baltimore Chapter CSI makes no endorsement of the opinions contained within this article.

What is Wrong with Brick Masonry Veneer Over Steel Studs?

by Clayford T. Grimm, PE¹

INTRODUCTION

Research has proven and field experience has confirmed that brick masonry veneer over steel stud (BMV/SS) wall system provides an unacceptable risk of performance failure in near term and catastrophic structural collapse in long term. Rigidity and low flexural strength of brick masonry combined with flexibility and high flexural strength of steel studs results in cracked masonry. Wind driven rain enters cracks, dissolves salts from masonry, crosses cavity on mortared anchors, and corrodes screws, which anchor masonry to studs. The only structural element holding masonry on the building is the fine, thin arris of a single thread of an abraded screw, which is periodically bathed in a salt solution. See Photographs. Corrosion is also caused by interstitial condensation, complete control of which is not feasible.³³ Corrosion water damage may include: dimensional change, efflorescence, cryptoflorescence, freeze-thaw spalling and splitting, increased heat transmission, condensation, deterioration of interior finishes, mold growth, and tenant inconvenience.

FIELD PERFORMANCE

Brick Institute of America (BIA) has reported an "inordinate" number of BMV/SS walls which have experienced severe cracking, leaking, spalling, tie failure, and collapse.¹ BIA has prepared a list of buildings having problems with brick masonry veneer over steel studs.² BIA is now into its third revision of *Technical Notes on Brick Construction* on BMV/SS wall system²⁸, each of which has recommended improved quality for design and construction. However, even current recommendations are said to be inadequate. "But even if these criteria are carefully followed, you can still expect problems from inadequate and corroded ties."²⁹ Latest BIA recommendations warn that system has "a great deal of potential for problems and distress" and recommends a detailed, careful inspection of such walls with every change of season or a least once a year.

National Concrete Masonry Association has issued a warning about system performance.³ Portland Cement Association has warned that, "Metal stud, masonry veneer system has some serious design deficiencies."²² Army Corps of Engineers prohibits use of BMV/SS on

military construction.³¹ US Department of Energy has issued a warning regarding failures of masonry veneer/steel stud walls in structures throughout the nation.¹⁹ State of Wisconsin does not use steel studs in exterior walls of new buildings because of many problems with the system.⁴ "A recent survey of engineers, architects, contractors, and building inspectors involved in construction indicated that several problems exist with this type of construction."¹⁷ "Recent performance of the veneer system has placed continued use of these wall systems in doubt, especially when steel stud backing is used."¹⁵ "A growing concern has developed regarding adequacy of current practices relating to brick veneer/steel stud wall ties."¹⁸ "Even minor design and construction errors in a steel stud wall can lead to structural failure."²¹

RULE-OF-THUMB DESIGN

BVM/SS wall system is typically designed for a deflection of 1/270th to 1/900th of masonry wall height.¹ Brick masonry is known to crack at about 1/2000th of wall height.⁵ Excessive deflection of flexible steel stud backup members can be transferred to masonry veneer and cause panels to deflect and crack.⁷ "Veneer cracking usually governs design of masonry veneer wall systems backed by steel studs."¹⁵

"Brick masonry veneer is typically built without inspection and with type N masonry cement mortar in which case the average crack probability was 82% for all cases studied, i.e. four such walls out of five will probably crack at design load. Use of non-air entrained portland cement-lime mortar and inspected workmanship reduced average crack probability to less than 10% for all cases studied. However, that probability is unacceptable because of the damage likely to be caused by water permeance in all but the most arid regions."²³

"Limiting the deflection of uniformly loaded steel studs to some portion of stud span is not a valid design method for the BMV/SS wall system, because:

1. The stud is not uniformly loaded (the top row anchors may carry a third of the total load on the wall);
2. Stiffness of masonry and of wall anchors are ignored;

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3. Deflection of a simply supported beam is a function of L^4 , not L ; and
4. Most importantly, the method does not accurately predict failure load.²³

"Only way the steel studs can properly participate in resisting lateral load would be for brick wythe to undergo flexural failure. This would result in leaky walls if not structural failure."¹⁴ "Although steel has sufficient strength to carry lateral wind loads, it may not do so without deflecting more than attached veneer can tolerate."³² "Steel studs and their fastenings may deflect enough under maximum wind pressure to cause cracking of brittle exterior facings such as brick or stone. Such cracking often leads to water leakage. Furthermore, if there is leakage through wall's facing layer because of cracking, porous masonry, or poor workmanship, studs and fasteners are susceptible to corrosion, and gypsum sheathing panels are subject to water deterioration."³⁰ "When used with masonry, studs must be rigid enough that cracks do not develop in masonry when walls are subjected to lateral loads."²⁴ Cladding panels must be designed so that they do not crack, buckle, or tear under peak static or fatigue loading.⁶

There is considerable anecdotal evidence against the BMV/SS wall system. Out of 250 open claims files involving exterior wall problems that (an) insurance carrier in Canada has, more than 100 are related to brick veneer/steel stud walls.²¹ A Canadian government survey of 160 Canadian architects, engineers, contractors, and building officials indicates that 84% believe that the system has not had adequate research. Sixty percent of respondents had reservations about using the system, and a dozen firms said they would not use the system, because they consider it to be unsafe. However, 20% are enthusiastic believers and users.²⁰

Table 1 lists failures of BVM/SS walls on 16 buildings investigated by Clayford T Grimm, PE, Inc. Certainly other forensic engineering firms could add to that list. BVM/SS walls often fail because they are so vulnerable to deviations from recommended good practice in materials, design, construction, or maintenance, e.g. improper anchorage, inadequate galvanizing of metal anchors, excessive anchor flexibility, high air content in mortar, raked mortar joints, absence of flashing end dams, unclean cavities, excessive spacing or absence of weep holes, unfilled mortar joints, and improper installation and maintenance of sealant joints. Of course, all of those anomalies occur in other masonry walls, however their effect is not so drastic. During one 30-day period in Austin, Texas, wind removed the brick masonry veneer from two buildings, because of improper veneer anchorage. During more than 40 years of concern with masonry, this writer has never heard of a cavity wall failure due to a connector deficiency.

RESEARCH

Corrosion of anchor screws, due to water leakage through cracked masonry and interstitial condensation, will ultimately make the wall life threatening. If veneer anchor screw threads are protected by corrosion resistant coating, that protection is abraded away in their self tapping, self drilling application. Tests on typical BMV/SS wall systems were conducted at McMaster's University under Canadian government sponsorship. Under typical winter conditions moisture was observed on stud and initial corrosion of galvanized screw and screw hole were found at 40% relative humidity after less than one week of testing.²⁷ "Brick veneer/steel stud wall

systems can deteriorate rapidly under effects of uncontrolled moisture accumulation. "There are no commercially available brick ties that satisfy necessary criteria of stiffness, strength, and corrosion resistance for the life of a building."²⁹

"The two most common moisture sources are: Rain penetration (and) moisture vapor condensation."¹⁶ "It has been demonstrated by laboratory tests that condensation on the stud can lead to the formation of rust where screw type fasteners pierce the stud."¹⁶ "A major problem affecting durability of the system is corrosion of metallic components, especially the structural ties."¹⁷ "Test results have indicated that air leakage rates well below values considered to be acceptable as airtight construction have shown accumulation of moisture and initiation of deterioration after only short periods of time."²⁷

"The construction of these (BMV/SS) walls has preceded development of adequate design, construction and inspection standards."²⁷ The wall system was introduced and promoted without adequate research, and behavior of the system is not generally well understood.⁸ Review of available research has indicated that brick veneer/steel stud construction has evolved without either adequate laboratory research or sufficient period of field testing.¹³ Test results show that current usual design procedure does not adequately account for actual behavior of the wall system.⁹ "Design guidelines, codes and standards are inadequate at the present time to deal with BMV/SS system, as a comprehensive design philosophy has not been adequately established or tested."²⁶ Until research results to the contrary become available, it is wise to use masonry backup walls of a stiffness greater than that of the brick masonry veneer, rather than steel backup walls.¹⁰

A DUTY TO WARN

In due course corrosion will destroy the structural integrity of the masonry veneer anchorage. When that occurs, the wall awaits the arrival of the 50 year wind. The brick masonry veneer wall then becomes life threatening.

Hybrid systems, like steel studs to support rigid brick veneer, warrant rational risk assessment and analysis of the consequences of failure.¹¹ The internationally prominent architectural and engineering firm of Smith, Hinchman & Grylls does not allow this type of construction and has warned the architectural profession that is their *duty* and right to inform the owner of potential risks in using brick masonry veneer over steel studs.¹² A Senior Associate with Albert Kahn Associates, Inc. says, "To back up the wall with light-gage stud construction that is subject to corrosion, will not stand up, in our opinion. We're going to see significant problems with this kind of construction within a 2-year period."²⁵

CONCLUSION

The solution is to design a masonry cavity wall. Stiffness of masonry interior wythe balances that of exterior wythe to prevent flexural cracking. In most cases, cost of masonry cavity wall is not greater than that of the BMV/SS system. Higher thermal storage capacity and greater fire resistance may effect savings to offset any initial cost differential.

This review of literature provides convincing evidence of high risk in use of the BMV/SS wall system. Society

requires that an architect or engineer do what a prudent person would have done under same or similar circumstances at a given time and place. Duty requires that the architect and engineer warn clients about risks inherent in the use of BMV/SS wall system.

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FAILURES OF BRICK MASONRY VENEER/STEEL STUD WALLS INVESTIGATION BY CLAYFORD T. GRIMM PE INC											
No	Year	Building	Type Service	State	Client	No	Year	Building	Type Service	State	Client
1	1977	apartment	investigation	NS	Owner	12	1987	office	investigation	TX	Developer
2	1978	hospital	investigation	KS	Contractor	13	1987	laboratory	investigation	MD	Contractor
3	1979	hospital	investigation	KS	Contractor	14	1988	hospital	investigation	TX	Owner
4	1981	condominium	investigation	MD	Owner	15	1990	hotel	investigation	TX	Owner
5	1983	office	investigation	TX	Owner	16	1990	hotel	investigation	GA	Owner
6	1984	housing	investigation	WI	Owner	17	1991	office	investigation	LA	Contractor
7	1984	hospital	investigation	FL	Contractor	18	1991	hotel	investigation	SC	Contractor
8	1985	apartment	investigation	TX	Owner	19	1991	hotel	investigation	FL	Architect
9	1985	apartment	investigation	TX	Owner	20	1991	hotel	investigation	FL	Architect
10	1985	office	investigation	TX	Developer	21	1992	hospital	investigation	MS	Owner
11	1986	office	investigation	TX	Contractor						

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