Building and Environment 46 (2011) 1047–1055

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Behavior of a mechanically anchored waterproofing membrane system under wind suction and uniform Pressure

Hiroyuki Miyauchi [a,*], Nobuo Katou [b], Kyoji Tanaka [c]

[a] Chungnam National University, 305-764 Daejeon, South Korea
[b] Tokyu Construction, 229-1124 Kanagawa, Japan
[c] Tokyo Institute of Technology, 226-8503 Kanagawa, Japan

ARTICLE INFO

Article history:
Received 17 July 2010
Received in revised form
6 November 2010
Accepted 11 November 2010
Available online 18 November 2010

Keywords:
Waterproofing membrane
Wind suction
Test method
Wind resistance
Force

ABSTRACT

A pressure and wind tunnel test was conducted to obtain the basic data for wind resistance design of a mechanically anchored waterproofing membrane system. The test specimen was a flat roof with the following dimensions: 2.4 m in width, 3 m in length and 0.29 m in height. The waterproofing material was polyvinyl chloride sheet reinforced with polyester fiber (PVC sheets). In the pressure test, because the applied pressure was equivalent to the pressure on the entire surface area of the roof, the billowing heights of the PVC sheet around the fastener had almost the same maximum values; therefore, the axial force at the fastener was also similar to the pressure induced by a compressor, and no lateral forces were measured. On the other hand, in the wind tunnel test, the strain of the PVC sheet around the fastener at windward side was larger than that of the leeward side. The lateral force was 70% of the axial force at a mean wind speed of 38.6 m/s. Therefore, it was clear that the characteristics of the mechanically anchored waterproofing membrane system in the pressure test and the wind tunnel test were different.

1. Introduction

Mechanically anchored waterproofing membrane systems have several advantages compared to the conventional systems, which use asphalt or adhesives to contact the entire surface of waterproofing membrane. Such advantages include the feature that mechanically anchored waterproofing membrane systems are directly fixed to the roof substrate with a series of fasteners. When the performance of these systems is compared to that of an adhered waterproofing membrane system, we observe that the mechanically anchored waterproofing membrane systems do not depend on the condition of the substrate to ensure adequate attachment to the roof. Construction areas using this system have achieved rapid growth, especially in repair and/or maintenance works [1]. However, they also face damages as a result of strong winds. High billowing of sheets caused by strong winds sometimes results in the tear of sheets or pullout of fasteners, because this anchoring system employs fasteners only at intervals of 50–100 cm to anchor waterproofing membrane sheets that cover the entire roof area.

An example in Japan is typhoon No.18 that struck in September of 2004, for which a maximum instantaneous wind speed of 60.2 m/s was recorded in the Hiroshima Prefecture, causing human causalities and severe property damage in various districts [2]. Several buildings that used waterproofing membranes for roofs and outer walls evidenced damage such as breakage or water leaking of the membranes. Thus, the working committee for waterproofing membrane systems of the Architectural Institute of Japan immediately started the 'WG Investigation of Waterproofing Membranes Damaged by Typhoons' and conducted a scientific investigation regarding the typhoon hazards to roofs and outer walls. The result of this investigation for typhoon No. 18 demonstrated that more cases of damage were observed along the route of the typhoon [2]. In addition, further damages were observed in regions where higher wind velocity was recorded, and numerous cases of damage to mechanically anchored waterproofing membrane systems were observed. On the other hand, members of the Roofing Committee on Weather Issues (RICOWI) reported three wind investigation projects on Hurricanes Ike, Katrina and Charley [3–5].

Therefore, for designing and building roofs using mechanically anchored waterproofing membrane systems, a significant concern remains the need to ensure safety against strong winds [2,6,7]. Currently, wind resistance safety for mechanically anchored systems has been verified by wind resistance tests, as per JASS8 [8], or by simplified wind resistance tests [9] based on dynamic wind pressure tests [10,11] in Japan. Wind uplift tests have been conducted to evaluate the effect of wind suctions of the mechanically

* Corresponding author. Tel.: +82 42 821 7732; fax: +82 42 823 9467.
E-mail address: miyauchi@cnu.ac.kr (H. Miyauchi).

0360-1323/$ – see front matter
doi:10.1016/j.buildenv.2010.11.005