

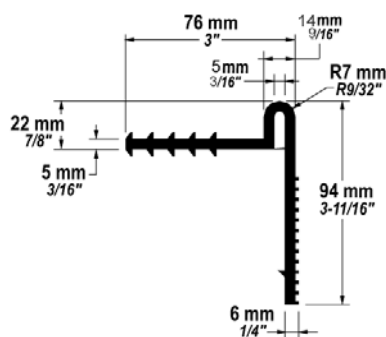


WESTEC®

Barrier Technologies

Testing of **Tearweb Retrofit Waterstop** for Secondary Containment

Booming oil and petrochemical markets have created a pressing need to upgrade or expand aging oil refineries and chemical plants. As a result, there is a growing need to prevent the release of hazardous waste from containment areas in compliance with various governing groups. Many designers are turning to Greenstreak engineers for guidance on proper waterstop detailing for expansion/isolation joints between new and existing concrete structures. A common application is the placement of a new concrete containment slab around an existing concrete tank foundation or ringwall. Differential settlement between the slab and foundation is often anticipated, thus requiring a waterstop that is able to maintain its seal after joint movement. The Westec brand #697 Tearweb Retrofit profile was designed specifically for this application. The function of the tearweb allows the waterstop to undergo significant joint movement without placing stress on the waterstop flange. Greenstreak engineers recently conducted extensive testing on the #697 profile to observe the amount of differential joint movement that the waterstop could accommodate prior to failure. Please review the following report for details.



**No. 697
Tearweb Retrofit**

Performance of Westec #697 Retrofit Waterstop Subjected to Differential Joint Movement

Report Prepared by Kyle Loyd on July 15, 2008

Section 1 - Objective

The purpose of this testing was to determine the amount of differential joint movement that the Westec #697 Tearweb Retrofit waterstop profile could safely accommodate without compromising the "fluid tightness" of the joint in which the waterstop was installed. In particular, this testing is relevant to applications where a new concrete containment slab is poured against an existing concrete tank foundation/ringwall and settlement/movement of the tank foundation/ringwall is expected. Another relevant application would be the placement of a new containment slab against an existing perimeter containment wall. In either case, these joints are often designed as isolation joints with no dowel restraint or load transfer capacity to allow the two concrete elements to move independent of one another. Essentially, this testing would be applicable to virtually any joint between an existing structure and a new concrete pour where joint movement is expected between the two elements. In addition to testing the amount of movement that the #697 waterstop can safely accommodate, test specimens were prepared to determine whether a heat-welded waterstop splice would compromise the performance of the waterstop system.

Section 2 - Test Specimen Construction

A total of 6 test specimens, referred to as "waterstop test beams" in this report, were constructed and poured per the figures shown below with the waterstop orientated as follows...

- Two test specimens constructed with the #697 profile orientated "right-side-up", which would position the tearweb bulb towards the top of the waterstop profile.
- Two test specimens constructed with the #697 profile orientated "upside-down", which would position the tearweb bulb towards the bottom of the waterstop profile.
- One test specimen orientated "right-side-up" with a heat-welded splice connecting two abutting lengths of #697. The splice was located at the middle of the test specimen. The intent of this test specimen was to observe the performance of the welded waterstop connection.
- One test specimen orientated "upside-down" with a heat-welded splice connecting two abutting lengths of #697. The splice was located at the middle of the test specimen. The intent of this test specimen was to observe the performance of the welded waterstop connection.

All waterstop test beams consisted of a 16-inch long by 12-inch wide by 6-inch deep center section with two identical end sections 8 inches long by 12-inch wide by 6-inch deep. The center section and two end sections were separated with ½-inch preformed joint filler with the #697 waterstop positioned within each of the two joints, anchored to the center section.

The center section was placed first. Form bulkheads at each end of the center section were removed one day after concrete placement of the center section. After form removal, Westec #697 waterstop was epoxied and anchored to each end of the center concrete section per Westec suggested #697 installation procedures. The waterstop was anchored using two 1/4"x2-1/4" stainless steel expansion anchor bolts spaced 6 inches apart, centered along the width of the test specimen, bolted against an 11-gage by 1-1/4" wide stainless steel batten bar. The bolts and bars used in the test were identical to those supplied with the #697 system.

The #697 was positioned in a manner to locate the ribbed waterstop flange at the center of the beam depth to facilitate 3 inches of concrete cover, top and bottom, of the ribbed waterstop flange. A piece of 1/2-inch thick bituminous preformed joint filler was positioned within the joint between pours to isolate the batten bars and anchor bolts of the #697 system from the second concrete pour and to create a 1/2" void between adjacent concrete placements. The 1/2" joint filler was adhered to the center concrete section using a 3M brand spray adhesive to prevent displacement during the placement of the end sections. Construction of the specimen was completed by pouring the two end sections of concrete.

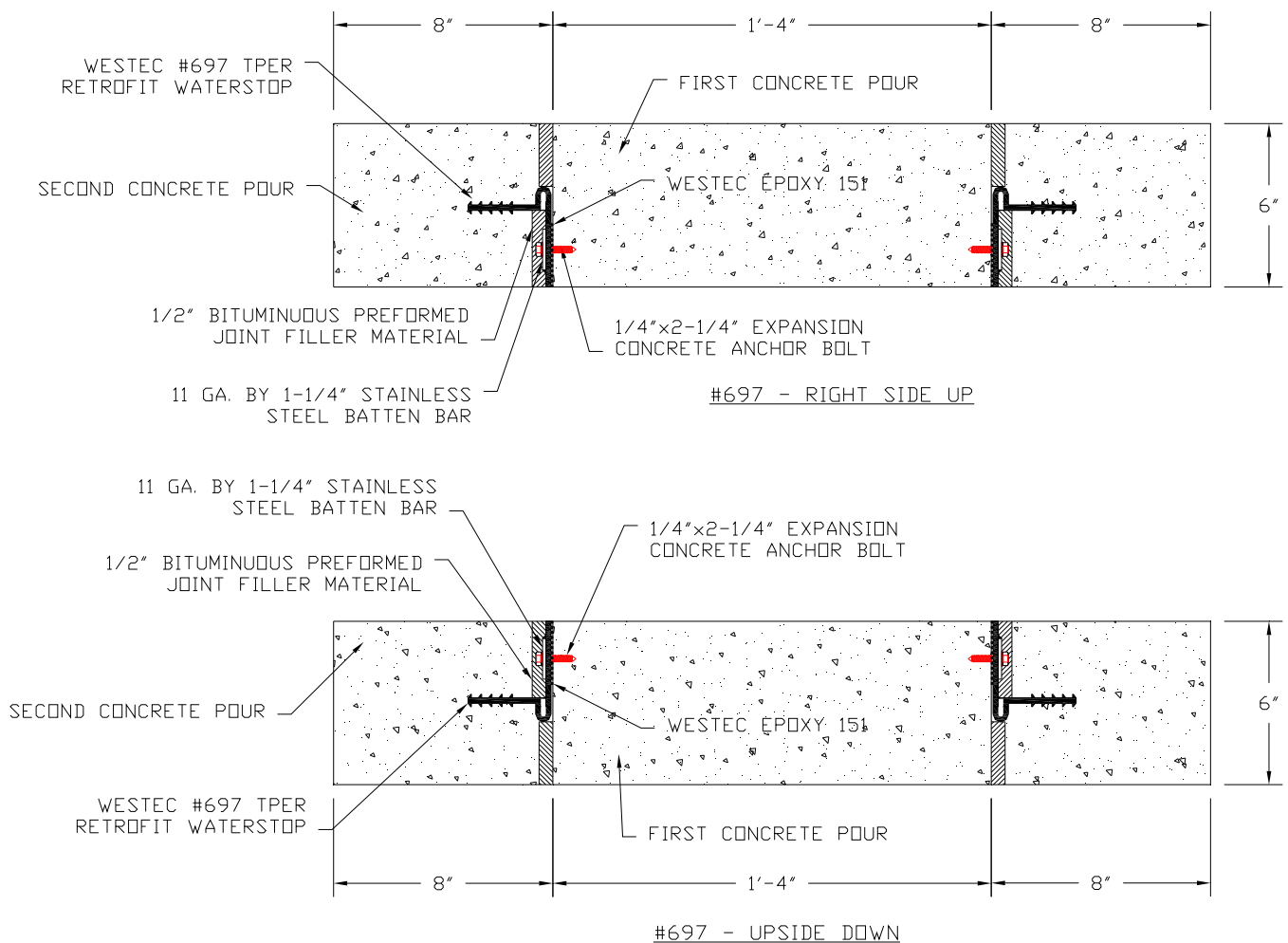


Figure 2.1 – Test Specimen Construction

Section 3 - Summary of Test Procedure

Testing occurred at the Greenstreak Group manufacturing facility and company headquarters in St. Louis, MO. The test apparatus used for this testing procedure is illustrated below. The waterstop test beam was positioned on a hydraulic press in a manner that supported the two end sections only, allowing the center section to displace freely when subjected to an external load applied by the hydraulic cylinder. Each end section was supported from below by four 4"x4" hollow structural steel sections, and held in a static position by restraining the section using a 6-ton bottle jack. The load was applied to the center section by a hydraulic cylinder. Deflection was measured using a tape measure and markings on the waterstop test beam spaced at 1-inch increments. Since only joint deflection measurements were relevant to the objective of this test, the force applied during the test procedure was not measured. Specifically, the deflection of the unsupported center section was measured to determine the deflection at the moment the tear web bulb ruptured, and also at the moment of apparent failure of the waterstop. The mode of failure was also noted.



Figure 3.1 - Test Apparatus with test specimen ready

Section 4 - Analysis

Deflection of the center section was measured using a tape measure and markings on the test specimens spaced at 1-inch increments. Measurements were taken for each specimen at the moment of tear web rupture (when the tearbulb opens) and at the observed failure of the waterstop, making note of the failure mode.

Test Specimen	Deflection at Tearweb Rupture	Deflection at waterstop failure	Failure Mode
#697 right-side-up	1 inch	2-1/2 inches	Rupture of waterstop at top of tearweb bulb
#697 right-side-up	1 inch	3 inches	Rupture of waterstop at top of tearweb bulb
#697 upside-down	1 inch	*3 inches	Rupture at waterstop flange
#697 upside-down	1 inch	**2 inches	Anchor bolts punctured through waterstop
#697 right-side-up with weld	1-1/4 inch	3 inches	Failed at waterstop weld, rupture of waterstop at top of tearweb bulb immediately after
#697 upside-down with weld	2 inch	**2-1/2 inches	Anchor bolts punctured through waterstop

*At 3 inches of joint movement, the joint displaced enough to observe that the actual waterstop flange had already ruptured. Actual amount of displacement at the moment of the waterstop flange rupture was unable to be measured since the point of rupture was not visible at the moment of rupture, but known to be less than 3 inches.

**Failure of waterstop was due to puncturing of the waterstop flange by the anchor bolts.

Table 4.1 – Testing Matrix

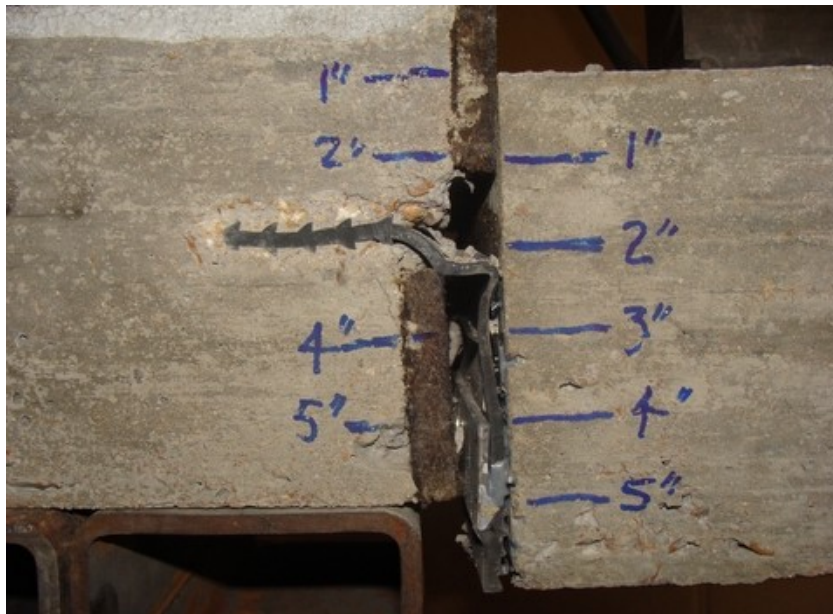


Figure 4.2 - Deflection at tearweb rupture



Figure 4.3 - Deflection approaching waterstop failure due to rupture in elongation

Conclusions

Although the failure modes were different, the resulting analysis showed that there was no significant advantage to the orientation of the waterstop positioned in the joint when considering maximum joint movement alone. It was observed that waterstop orientated right-side-up in the test specimens typically failed at the top portion of the tear web bulb as a result of a failure in elongation. Waterstop orientated upside-down in the test specimens typically failed due to the anchor bolts puncturing through the waterstop flange. A joint gap wider than the $\frac{1}{2}$ " in this test would most likely result in a greater joint deflection before the anchor bolts would penetrate the waterstop when orientated upside-down. However, this would decrease the waterstop flange embedment in the second concrete pour, which would diminish the maximum head pressure rating of the waterstop.

It was also observed that none of the test specimens resulted in an anchor bolt failure. Thus, the $\frac{1}{4}$ "x2-1/4" expansion anchor bolts provided with the #697 system and used in all test samples appear to be adequate when spaced 6 inches on center as suggested in the Westec #697 installation guide.

None of the test specimens showed signs of concrete pullout of the waterstop flange at any magnitude of joint deflection, even at waterstop rupture. Nor did the waterstop flange "neck down" in its thickness, allowing the waterstop flange to remain in intimate contact with adjacent concrete throughout the entire width of the embedded portion of the waterstop flange. This is important to the overall performance of the waterstop system when subjected to substantial joint movement.

Maximum joint deflection did not appear to be compromised on the two test specimens with a heat-welded waterstop splice. This was the expected result, but testing analysis supported that theory.

Based on the resulting analysis, it would appear that the Westec #697 Tearweb Retrofit waterstop system could conservatively accommodate 1-1/2" of differential joint movement when installed in a 1/2" isolation joint regardless of waterstop orientation. When jobsite conditions allow, it is suggested positioning the waterstop in an orientation that locates the anchor bolts and batten bar to the "dry" side of the joint. Although head pressure ratings were not tested, a decrease in maximum head pressure capacity would be expected with increased joint deflection as the unrestrained area of waterstop within the 1/2" joint gap will elongate and decrease in thickness.

Disclaimer

The contents of this report do not represent a warranty of the products used in the test procedure. The data and conclusions are for general informational purposes only and should not be used without competent advice with respect to their suitability for any given application. Therefore, the responsibility for the use of the information in the presented report remains with the user. The report is intended for informational purpose only and is made available with the understanding that it will not be altered without the permission of Greenstreak Group, Inc. This information is proprietary and shall not be copied or used for any purpose not authorized in writing by Greenstreak Group, Inc.



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