EVALUATION CRITERIA FOR Twisted Steel Micro Rebar (TSMR) CONCRETE

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PREFACE

Evaluation reports are based upon performance features of the International family of codes and other widely adopted code families, including the Uniform Codes, the BOCA National Codes, and the SBCCI Standard Codes. Section 104.11 of the International Building Codes reads as follows:

The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Similar provisions are contained in the Uniform Codes, the National Codes, and the Standard Codes.
1.0 INTRODUCTION

1.1 Purpose: The purpose of this evaluation criteria is to establish requirements for Twisted Steel Micro Rebar an independently reviewed evaluation report under the 2006 International Building Code® (IBC) and the 2006 International Residential Code® (IRC). Basis of recognition is the IBC and IRC Section 104.11.

1.2 Scope: This evaluation criteria applies to Micro Rebar used as reinforcement in concrete in lieu of ACI methods for structural concrete and for in structural slabs on grade (applications not covered by ACI 318 but covered in ACI 360)

1.3 Codes and Reference Standards


1.3.2 2009 International Residential Code® (IBC), International Code Council.

1.3.3 ASTM 192
1.3.4 ASTM C 192
1.3.5 ASTM C 39
1.3.6 ASTM C 173
1.3.7 ASTM C 138
1.3.8 ACI 318-08
1.3.9 ASTM C 78
1.3.10 ASTM E111
1.3.11 ACI 224.2
1.3.12 AS 3600

1.4 Definitions:

1.4.1 Twisted Steel Micro Rebar (TSMR) must be made of steel, it must have a non-circular cross section and must be twisted at least one time about its own axis. It is typically small enough to be mixed in large numbers into the concrete prior to pouring.

1.4.2 Twisted Steel Micro Rebar Design Crack Width, Sa. This is the crack width tensile stress typically measured for structural design applications. Sa represents the average upper limit of displacement in a direct tension test where the stress remains stable. Sa is defined as: [Material Elongation as stated on raw material cert + X (elongation from twist – Equation 1)] / 3. This represents the materials approximate ability to “stretch” and need not be exactly determined. It is used a reference point for computing tensile resistance and compute maximum allowable crack width. In general the larger the Sa selected, the smaller the tensile resistance and the larger the maximum allowable crack width.

Equation 1

\[ X = 1 - \cos\left(\frac{n2\pi d}{L}\right) \]

Where

n= number of full revolutions of the part

d= equivalent diameter of the wire

L= length of the part

X= percentage reduction in length from twisting the part

1.4.3 Hybrid Design – A design that includes a combination of both traditional rebar and TSMR.

1.4.4 TSMR Design Classes – there are four TSMR design classes. The engineer must select the appropriate design class based on the definitions below.

1.4.4.1. Class A - Secondary Reinforcement: As a replacement for rebar or mesh in any application as an alternative to minimum reinforcement for the shrinkage and temperature reinforcement specified in Section 7.12 of ACI 318 (IBC and IRC) 12 and UBC Section 1922.3 (AS3600 – 9.4.3). This includes as replacement for temperature and shrinkage reinforcement in composite steel deck applications specified in ANSI/SDI-C1.0 and other structural plain concrete structures designed according to ACI 318 Chapter 22 (AS3600 – 16). The TSMR Micro-Rebar must not be used to replace any joints specified in IBC Section 1909.3.

1.4.4.2. Class B - Minimum Structural Reinforcement. As a replacement for structural reinforcement in soil supported structures including, footings, structural concrete slabs supported directly on the ground (designed using ACI 360-10 Section 11.3.3, 2 Elastic Method), foundations, replacement for
structural reinforcement in members in which arch action provides compression. Replacement of reinforcement in pile supported slab on ground with no occupiable space beneath designed per ACI 318 and as replacement for reinforcement in structural walls per ACI 318 Chapter 14 (AS3600 Section 11) meeting the following criteria:

- Thickness of bearing walls shall be not less than 1/24 the unsupported height or length, whichever is shorter.
- Walls shall be braced against lateral translation (walls must be laterally supported in such a manner as to prohibit relative lateral displacement at top and bottom or on both sides of individual wall elements).
- At least one No. 5 (16 mm) bar shall be provided around all window, door, and similar sized openings. The bar shall be anchored to develop $f_p$ in tension at the corners of openings.

As replacement for the minimum structural reinforcement in walls per 21.7.2-5 (AS3600 – 9.1.1) when the above requirements are met.

1.4.5 **Class C** – Structural Concrete As reinforcement for all other structural concrete including in unsupported horizontal spans.

1.4.6 **Class Cs** – Non-Linear Slab Design As reinforcement in structural slabs on ground designed in accordance with ACI 360-10 chapter 11.3.3 Methods 2 (Yield Line Analysis) and 4 (Nonlinear Finite Element Analysis).

### 2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted:

2.2 Product Description: The test product is Micro Rebar as defined in Section 1.4.1 above. The following information shall be included in the evaluation report:

2.2.1 Raw Material Tensile Strength: The evaluator will report the tensile strength for raw material certification supplied by the manufacturer.

2.2.2 Description of Shape: The evaluator will verify the cross sectional shape non-circular (it has at least one flat edge).

2.2.3 Cross Sectional Area: The evaluator will compute this from the diameter reported on the raw material certification.

2.2.4 Minimum twist: The evaluator will visually inspect and make sure there is at least 1 360-degree twist over the length of the product.

2.2.5 Fire Resistance: Twisted Steel Micro Rebar shall have UL listing for Fire resistance under UL263 at least one roof and floor design. Fire testing specific to the application is not required because the test establishes the equivalency of the product to rebar in terms of fire resistance.

2.3 Installation Instructions:

The manufacturer shall provide the reviewer and the laboratory conducting the testing a copy of its installation instructions. When preparing test specimens, the same manufacturer provided installation instructions and procedures used in the field should be used.

2.4 Packaging and Identification: Method(s) of packaging and product identification shall include be included in the evaluation report.

2.5 Testing Laboratories: Testing laboratories shall be accredited as complying with ISO/IEC Standard 17025 for the testing reported by an accreditation body conforming to ISO/IEC 17011.

2.5.1 Test Reports: Test reports shall comply with UES Test Report Requirements Procedure No. ES-025. In addition, the test reports shall include sampling procedures, test specimen preparation including the concrete mix proportions, test procedures and results of all tests.

2.5.2 Product Sampling: Sampling of the Twisted Steel Micro Rebar for tests under these criteria shall be by the laboratory.

### 3.0 TEST AND PERFORMANCE REQUIREMENTS –

3.1 Micro Rebar Material - Per description in Section 1.4.1.

3.2 Coupon
3.2.1 Samples shall be molded in a non-absorptive mold with the use of a form release agent. Similar to Figure “1”).
3.2.2 Samples to remain in the molds for a period of 24 hours after casting and then cured in accordance with ASTM C 192.
3.2.3 A universal joint shall be positioned at one end of the test specimen (Figure “1”) 
3.2.4 A minimum of three (3) displacement measuring instruments shall be attached to the specimen to provide the actual displacement of the actual specimen (Figure “1”)
3.3 Concrete compressive strength 
3.3.1 Compressive strength samples to be cast cured and tested in accordance with applicable sections of ASTM C192 and C 39 respectively.
3.4 Anchoring 
3.4.1 Coupon is to be anchored with a threaded rod hardened with an embedment of 3.5” (90 mm) using a chemical anchor with bond strength high enough to prevent pullout failure of the anchor. Anchor to be installed and cured in accordance with chemical anchor manufacturer instructions prior to testing of the concrete sample.
3.5 Test Machine – A universal tension tester is required to complete the tests
3.5.1 Machine shall be capable of a sampling rate of 0.1hz minimum.
3.5.2 Machine shall be capable of .0005 in/min (0.0127 mm/min) deflection rate.
3.5.3 Machine shall be able to deflect at least .25 inches (7 mm)
3.5.4 Machine shall be capable of containing the coupon shown in Fig 3.
3.5.5 Three displacement measuring devices with a resolution of 0.1 microns and an accuracy of 1 micron. See figure “1” for approximate location of LVDT. The LVDTs must be centered about the center of the gage length of the tension specimen.
3.5.6 All tests in concrete shall be conducted using appropriate sections of the reference mix outlines in Sections 11 through 15 of ASTM C 494. For structural lightweight concrete, aggregate shall comply with ASTM C 330, size designation 1 in (25.0 mm) to 4.75 mm (0.187).

4.0 TEST METHODS 
Lab inspection:
4.1 Direct Tensile Test- Testing shall be conducted in room temperature in accordance with ASTM E111-04 (2010), “Standard Test Method for Young’s Modulus, Tangent Modulus, and Chord Modulus.” Tensile Test in shall be carried out by deflecting the coupon held by the crosshead at a rate of .0005 in/min (0.0127 mm/min) up to a deflection of .007 in (0.178 mm). The speed shall then be increased to .01 in/min (0.25 mm/min) up to a deflection of .20 inches (5 mm). The ASTM E111-04 reporting requirements listed in Section 10.1.8 and Section 10.1.9 shall be replaced with the following reporting requirements.
4.1.1 Tensile Force Vs. Elongation Curve 
4.1.2 Determine Peak Tensile Force
4.1.3 Determine the Tensile force and displacement immediately preceding the formation of the first dominant crack. Compute associated stress and strain values based on the section size and gage length.
4.1.4 Determine the peak post crack tensile strength. This is defined as the peak load after 0.01” (0.25 mm) displacement.
4.1.5 Determine tensile force at the strain limit (defined as 5a)
4.1.6 After the specimen is broken count the total number of TSMR on both faces of the broken section extending out of the broken plane at least 0.040” (1 mm) and at 30 degrees or greater (90 degrees defined as the TSMR being perpendicular to the cracked plane)

4.2 Concrete Mix Compressive Tests – Three 6” diameter cylinders shall be tested for each unique mix design within 24 hours of tensile testing. Compute the design compressive strength. The actual cylinder tests must be reduced to the design compressive strength per ACI 318-08 5.3.2.2.

5.0 TEST DATA ANALYSIS
5.1 Establish a general linear regression model that predicts the tensile force as a function of
1) the number of Micro Rebar present in the broken section per 4.1.6 and 2) the design compressive strength concrete.

5.1.1 Report the linear terms, the constant and the standard deviation of both.

5.1.2 There is no minimum or maximum number of tests required, however, enough tests must be run to establish the number of Micro Rebar linear term as a statistically significant predictor (the maximum allowable p-value of this term is 0.05 indicating 95% significance).

5.1.3 Outliers and suspicious data points may be removed using standard statistical practices. Outliers may not be removed from the test report and their removal from the regression model must be justified in writing along with the regression analysis results.

5.1.4 The overall average number of TSMR (defined in 4.1.6 above) in the tests may not exceed the midpoint of the range of TSMR per unit area considered (the dosage may have a bias toward the upper half of the range).

6.0 FIELD INSPECTION:

6.1 Micro-Rebar dosage (mass per unit volume applied to the mix) to be certified in writing by concrete supplier.

6.2 Verify the compressive strength is at least 3000 psi (20 Mpa).

6.3 Compressive strength samples to be cast cured and tested in accordance with applicable sections of ASTM C192 and C 39 respectively.

6.4 In situ inspection of TSMR content is not required for TSMR designs because the restrictions limit the users to applications where one of three conditions exist which guarantee stability: soil support, lateral support, arch geometry (requirements set forth in ACI 318-08 Chapter 22.2.1) or presence of minimum structural rebar.

7.0 QUALITY CONTROL

7.1 Quality documentation complying with the UES-010, MinimumRequirements for Listee’s Quality Assurance System shall be submitted for each facility manufacturing or labeling products that are recognized in the evaluation report.

7.2 A qualifying inspection shall be conducted at each manufacturing facility inspection agencies accredited as complying with ISO/IEC Standard 17020 by an accreditation body conforming to ISO/IEC 17011.

7.3 An annual inspection shall be conducted at each manufacturing facility.

8.0 PERFORMANCE REQUIREMENTS

8.1 Strain Capacity Increase Requirement - Tensile tests must indicate a statically significant increase (minimum of 95% confidence, the maximum p-value in a two sample t-test, 0.05) in tensile strain capacity versus baseline (plain concrete). A minimum of 6 control (plain) samples must be considered in the analysis in addition to the minimum number of TSMR samples required in Section 4. Since resolution of data can be an issue in measurements of small deflections data with slope COV greater than 2% as computed per ASTM E111-04 (Section 9.2 Equation 4) may be neglected.

8.2 Post-Crack Tensile Stability Requirement. Tensile tests must indicate that the median of the load carried at Sa divided by the peak load after 0.01 mm displacement is equal to or greater than 0.85. This is an indication that of stable tensile response below Sa.

9.0 APPLICATION

9.1 Analytical Model - Standard ACI practices for computing bending moment and shear (or any other resistance value based on the tensile strength of the concrete) shall be used replacing the tensile contribution of the conventional reinforcement with the TSMR tensile force. The engineer shall use the following procedure to design with TSMR.

9.1.1 Compute the nominal area of steel for the application using standard practice assuming standard rebar.

9.1.1.1 For Class A design the engineer may choose to assume the rebar is the center of the concrete section.

9.1.1.2 For Class B, C and Cs structures the engineer determine the area of steel require at the depth of the centroid of the tension region of the concrete section.
9.1.2 Area of Steel Vs. TSMR Count Table: The evaluation report will include a table for each class of design which includes at a minimum two columns 1) area of Rebar and 2) number of Twisted Steel Micro Rebar required to provide the equivalent yielding force of the area of rebar listed in column 1. The engineer uses this table to compute the number of TSMR required to provide the tensile resistance equal to a given area of standard rebar. This table may have additional columns for different concrete compressive strengths. The manufacturer will prepare the tables and the evaluator will verify the following: The force per TSMR is determined using the regression model developed in section 9.1.2.1. Class A&B: Micro-crack occurs and the TSMR remains bonded to the concrete (true composite action). The average embedded length is ½ the length of the TSMR. The tensile test, measures the response when the average embedded length is only ⅔ the length of the TSMR due to the formation of a dominant crack. To obtain the maximum resistance, multiply the tensile force at Sa by the ratio of the embedded lengths: L/2 divided by L/4 = 2 to obtain the force per TSMR.

9.1.2.2. Class C and Cs: Assumes a multiple crack condition with areas of localization. When this occurs the average embedded length becomes L/4 just as it is in the tensile test at Sa due to the presence of a full depth crack so no adjustment is needed Sa is used as the force per TSMR.

9.1.3 TSMR Count / Unit Area Vs. Dosage Table: The evaluation report will include a table for each class of design, which includes at a minimum two columns 1) number of Twisted Steel Micro Rebar per unit area 2) TSMR dosage required to provide the number of TSMR listed in column 1. Additional columns may be provided to for different compressive strength concrete. The engineer divides the number of TSMR required by the area of concrete in tension and uses this table to determine the Twisted Steel Micro Rebar’s dosage that needs to be applied.

9.1.3.1. The percentage of TSMR active in resisting tension shall be 88.9 % (percentage of all TSMR inclined 30 degrees or more relative to the direction of the load).

9.1.3.2. The manufacturer may elect to conduct a series of tests as described in section 4.1.11 to establish the COV at various dosages and present the results to the reviewer. A third party testing agency, customer or university must perform tests used for calibration purposes.

9.1.3.3. In the absence of actual distribution data the manufacturer may elect to use data available in literature (Dupont, L. Vandewalle / Cement & Concrete Composites 27 (2005) 391–398) and use a non-linear power fit with an upper extreme of 25% at low dosage (0.1% volume fraction) and an upper extreme of about 3% the upper limit (about 1% volume fraction).

9.1.4 TSMR Count / Unit Area Vs. Tensile Stress Table: The evaluation report may optionally include a third table, which relates the number of TSMR per unit area to the tensile stress it provides. Additional columns may be provided for different strength concrete.

9.1.5 A factor of safety shall be applied the table values to address the variance in Micro Rebar performance in Class B and C only, average responses are used for Class A and Cs. The factor of safety shall be computed using standard LRFD statistical methods such that the force the tensile strength provided by Micro-Rebar may be substituted into the design equations for rebar. A table separate table must be prepared for each design class.

Equation 2
\[ \varphi = e^{-0.75 \beta V_r} \]

Where
\( \varphi \) is the target resistance factor
\( \beta \) is the beta factor defining the acceptable probability of failure (see section 9.2).
\( V_r \) is combined coefficient of variation of the response model. The coefficient of variation shall be computed using appropriate statistical laws as outlined by MacGregor (MacGregor, J.G. Safety and limit states design for reinforced concrete, Can. J. Civ. Eng. 3, 284 (1976))

9.2 Resistance Factor Calibration

9.2.1 It is generally accepted that prediction of bending response from direct tension response can be overly conservative in concrete because direct tension tests do not allow as much re-distribution of load as bending test allow. The manufacturer may optionally choose calibrate the class B and C beta values based on experience from laboratory and field-testing to correct for this offset. Calibration is done by comparing bending moments predicted using the TSMR tensile stress quantities applied as a rectangular stress block below the neutral axis to the peak and the average post crack bending moments of 3 or 4 point tests (with simple supports – e.g. ASTM C1609, ASTM C78, JSCE SF-4, full scale bending tests, etc).

9.2.1.1. (The average post crack bending moment shall be computed as the average of the 1) peak moment, 2) the moment at the midpoint deflection corresponding to a single crack width equal to 5a and 3) the moment at half of this midpoint displacement). The overall average factor of safety versus the 1) peak and 2) average post crack strength. The mid-point deflection may be determined using the following similar triangles approach.

Equation 3

\[ \text{crack width} = 4 x \frac{h \times \delta}{\text{span}} \]

where
\( h \) is the height of the beam
\( \delta \) is the mid-span deflection
\( \text{span} \) is the unsupported distance between supports.

9.2.1.2. Class A and Class Cs designs are based on average values so they beta shall be set to zero for these design classes. No calibration is required for these classes.

9.2.1.3. Class B design is based on micro-cracking behavior so it shall have a minimum an average factor of safety Vs. peak of 4 with less than 1:20 over predictions (based on beta 1.5 at peak). The beta may be adjusted this requirement is met.

9.2.1.4. Class C design is assumes some localization so it shall have a minimum average factor of safety vs. average post crack strength of 2 with less than 1:20 over predictions (based on beta exceeding 1.5 at average post crack). The beta may be adjusted this requirement is met.

9.2.1.5. A third party testing agency, customer or university must perform tests used for calibration purposes. Since the purpose of calibration is to adjust the model to real life performance and actual users conduct many of these tests, it is impractical to require these tests be conducted at IAS certified facilities. The testing agency need not meet the requirements of UES-025 provided test results summary sheets are provided and a third party professional engineer reviews the data and calibration computations and agrees with the manufacturer’s results.

9.2.2 Default Beta levels: In the absence of at least 20 test results from at least 2 difference sources meeting the above requirements for calibration,
the following default beta values must be used.

- Class A: \( \beta = 0 \),
- Class B: \( \beta = 1.5 \),
- Class C: \( \beta = 1.5 \),
- Class Cs: \( \beta = 0 \),

Note these beta values are lower than traditional beta levels for rebar reinforces structures because the support requirements and minimum rebar requirements outlined in section 10.0 limit the users to applications where one of three conditions exist which guarantee stability: soil support, lateral support, arch geometry (requirements set forth in ACI 318-08 Chapter 22.2.1) or presence of minimum structural rebar. These limitations eliminate from consideration a collapse limit state caused by failure of TSMR to provide rated tensile strength that would have required a higher beta. A much lower beta therefore is permissible since failure will never result in collapse, the worst-case being a crack that may eventually require repair.

9.2.3 Performance based alternative. The design criteria outlined above as well as the limitations below may be waived if engineer shows through testing and/or analysis adequate strength for the factored loads and serviceability requirement.

10.0 LIMITATIONS

10.1 Class Application Limits. The allowable applications for each class are described in detail in 1.4.3.

10.2 Strain Limits: Class A & B Strain Limits: The average tensile strain in the concrete is not to exceed the average increase in tensile strain determined through direct tension testing (section 8.1). The average tensile strain in may be estimated by dividing the tensile stress in the concrete by the modulus of elasticity of the concrete (Hooke’s Law) and maximum tensile strain. If the limit is not satisfied, class C design is required. For Class A & B use Table 3 to select the provided Helix unit tensile strength and calculate the average strain with the following formula:

\[
\varepsilon = \frac{\text{Helix tensile stress}}{E_{CT}}
\]

Where:
- \( E_a \) is the tensile modulus of elasticity of Helix concrete estimated as 57000 \( \sqrt{f'c} \) (psi) or 4200 \( \sqrt{f'c} \) (MPa).
- \( \varepsilon \) the average concrete tensile strain

Note: this computation is not meant to be a predictor of crack formation but rather a predictor of the concrete’s ability to redistribute loads by having at least enough tensile strain capacity at the centroid of the tensile region to resist formation of a full depth dominant cracks. These types of cracks eliminate alternative load paths and the ability for the loads to re-distribute.

Baseline tensile strain capacity shall be set at 83 micro-strain (0.000070). This is based on ACI’s equations for the direct tensile strength of normal weight concrete (ACI 224.2R-92 Equation 3.2) and \( E_c \) (ACI 318-08 8.5.1). The TSMR strain limit is set at one plus the percent increase (section 8.1) x this baseline.

While the equations provide some differences for light-weight concrete the change is not significant enough to require re-computation of the baseline strain. The strain increases with TMSR dosage. A simple regression should be performed to establish three strain limits based on average increase in strain within each range versus TMSR content per unit area. The strain increase shall not exceed the 90th percentile of all data collected for the strain increase check in section 8.1.

In cases of pre/post tensioning the initial compressive strain may be subtracted from Equation 4. In cases of restrained shrinkage and/or joint-less slabs, the estimated shrinkage strain must be added to the strain computed from Equation 4. Several methods of strain computation are available. It is up to the discretion of the engineer on how to compute these tensile strain values.

10.3 Class C Structure Limitations

10.3.1 Bar reinforcement is not required in any structure which exceeds the class A or B strain limits but meets the class A or B applications limitations.
listed 1.4.4.1 and 1.4.4.2. The engineer, may, however elect to use a combination of bar reinforcement and TSMR for these applications.

10.3.2 Bar reinforcement is required in any structure not meeting class A and B application limitations listed 1.4.4.1 and 1.4.4.2. The minimum of the amount prescribed in ACI 318-08 section 10.5.1 (AS3600 8.1.6.1) other applicable code minimum structural reinforcement for the application.

10.3.3 Unsupported horizontal spans (free-spanning beams or slabs with occupiable space beneath) shall have the minimum amount of bar reinforcement required to carry nominal service loads.

10.3.4 Strength provided by non-composite stay in-place forms applications not meeting the class A&B application limitations may be used to satisfy the minimum reinforcement requirement provided the engineer shows the forms provide resistance equal to or greater than the resistance provided by the required bar reinforcement however the TSMR dosage must be adequate to carry the entire load (the contribution of the stay in place forms should not be added to the capacity).

10.3.5 The requirement for rebar may be waived if a test is conducted in accordance with section 9.2.3.

10.4 Class A & B Hybrid Design

10.4.1 Hybrid design is allowed for class A&B structures with no minimum rebar requirement when the application limits listed in sections 1.4.4.1 and 1.4.4.2 and strain limit in section 10.2 is met.

10.4.2 If class A or B application limits (listed in sections 1.4.4.1 and 1.4.4.2) are satisfied but the strain limit in section 10.2 is exceeded, may be designed as Class B Hybrid. (This will reduce the strain computed in section 9.2.3). The strain limit may be waived if the minimum amount bar reinforcement as prescribed in ACI 318-05 section 10.5.1 (AS3600 8.1.6.1) is provided. Alternatively, the engineer may elect to use Class C without the need for bar reinforcement.

10.5 Minimum and Maximum Dosages and concrete compressive strengths shall be set at levels consistent with the upper and lower bounds of the tensile testing program. Extrapolation above and below the tested TSMR compressive strength and count may not exceed 20%.

10.6 For flexure, standard balanced and tension controlled limits as prescribed in ACI 318-08 Section 10.3 apply.

10.7 Shear Restrictions

10.7.1 Class A and Cs are not allowed for design Helix dosages for replacing shear reinforcement.

10.7.2 The contribution of plain concrete to shall be neglected in applications like shear (do not add $V_c$ to the shear resistance computed for TSMR). The direct tension tests used to characterize the material include the effect of the concrete.

10.7.3 Area in tension should be taken as the 1.41 x the section width x height minus 4 inches (100 mm). This represents the 45-degree plane between the two layers of original reinforcement.

10.8 A registered professional engineer must approve use of TSMR Micro-Rebar.

10.9 Precast Concrete – TSMR may not be used to replace supplemental rebar placed around openings and tied to lifting points. Precast may be designs as class B even if the class B application limitations are exceeded if testing is conducted to show the desired strength and serviceability requirements are met.

10.10 When TSMR Micro-Rebar is added at the ready-mix plant, a batch ticket signed by a ready-mix representative must be available to the code official upon request. The delivery ticket must include, in addition to the items noted in ASTM C 94, the type and amount of TSMR Micro-Rebar added to the concrete mix.

11.0 Evaluation Report Recognition- The Evaluation Report shall include the following:

11.1 Basic information required by section 2.0 including product description, packaging and identification.

11.2 Description of TSMR design classes and application limits (Section 1.4.3)

11.3 Design Instructions and Tables (Section 9.0)
11.4 Conditions of Use (Section 10.0)

12.0 Acceptance Criteria – TSMR must pass both tests described in Section 8.0 of this report.
Figure 1: Tension Specimen Molds