A structural support system consisting of a bridging structural element and two (2) or more frangible elements providing fatigue and/or shock load(s) capacities utilized as a structural jointing between a foundation and a superstructure.
FIG. 2

BREAKAWAY BASE SUPPORT SYSTEM FOR HIGHWAY SIGNS

MD 821.06

NOTES:
1. THE BRACKET NUMBER IS STAMPED ON THE BRACKET.
2. BOLT THE BRACKETS TO POST, THEN PLACE POST AND CONNECTED BRACKET TO BREAKAWAY COUPLING.
3. ALL BOLTS TO BE TIGHTENED IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATIONS.
4. REFER TO APPROPRIATE N00 SERIES STANDARD PLATE FOR HANGING PLATE, SHAW AND BRACKET DETAILS.
5. REFER TO APPROPRIATE N00 SERIES STANDARD PLATE FOR ANCHOR, BREAKAWAY COUPLING AND COUPLING BOLT DETAILS.
6. REFER TO APPROPRIATE N00 SERIES STANDARD PLATE FOR ADJUSTMENTS TO CONCRETE FOUNDATIONS TO SUIT VARIOUS GROUND SLOPES.
7. REFER TO APPROPRIATE N00 SERIES STANDARD PLATE FOR MATERIALS.
FIG. 4

FATIGUE PLATE

Plan View
FIG. 5

FATIGUE PLATE

SIDE VIEW

POST BASE DETAIL

TOP OF FATIGUE PLATE

Plan View
FIG. 7

COUPLING BOLT DETAIL

13/16" DIA. 45° (TYP.)
1/16" - 8 UNC -2A

BREAKAWAY BASE SUPPORT SYSTEM FOR HIGHWAY SIGNS

MD 821.04
FIG. 13  

FATIGUE PLATE

---

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
9. 

SIDE VIEW

POST BASE DETAIL

GROUND LINE

TOP OF FATIGUE PLATE
Fig. 28

(a)

(b)

(c)

Fig. 106
STRUCTURAL SUPPORT SYSTEM

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FIELD OF THE INVENTION

The present invention relates generally to fatigue load and/or shock load resistant structure frangible connections and specifically to post and portal-frame superstructure jointing to foundation providing breakaway functionality with fatigue and/or shock load resistance particularly when such loads are generally lateral in nature.

BACKGROUND OF THE INVENTION

The present invention provides solutions for laterally loaded structures subjected to fatigue-loads and/or shock-loads in addition to typically encountered service-loads and specifically to problems with roadside devices equipped with frangible structural connections to their foundations identified thru recent full-scale testing performed by the present inventor, confirmed by independent third-party testing, and approved by the U.S. Federal Highway Administration (FHWA) for use on the National Highway System (NHS).

The present invention is the fruit of a decade of methodical, persistent analytical, modeling, and full-scale test engineering investigation regime whose yield of unexpected results have been confirmed by U.S. FHWA recognized, independent third-party, testing and by independent testing by numerous accredited American civil engineering universities laboratories.

Successful structural design applications intending to mitigate fatigue and/or shock loadings on brittle or frangible superstructures date back to at least the 5th Century B.C. with the incorporation of a 3 inch by 4½ inch by 6 foot iron beam set in a groove with sufficient depth to allow said beam to deflect under dynamic loads, spanning column capitals in the Propylaea in Athens, Greece. A larger iron beam, this one 3 inches by 5 inches with a clear span of more than 13 feet, was incorporated in the Temple of Apollo at Bassae five or so years later in approximately 430 B.C. The Bassae beam was also hidden from view in a U-shaped trough of sufficient depth to allow significant dynamic deflection. Such ancient engineering applications’ longevity proves out how such design dumps-out and sustains brittle and/or frangible superstructures, such as the marble of the above mentioned Greece temples from shock-loadings associated with earthquake and similar load conditions.

OTHER PATENTS

ES2216093T, to Gasparetto-Stori and Serafin, published Oct. 16, 2004

RELATED DOCUMENTS

5. U.S. Federal Highway Administration Findings Letter B123
10. The present invention applies the lessons, taught by the Propylaea’s architect Mnesicles, to struc-
turally separate brittle or frangible superstructures subjected to shock loads from its foundations via damping throught intermediate flexure of a bridging structural jointing.

[0017] Examples of everyday devices subjected to shock loads are highway sign structural supports, highway bridge railings and such like located equipment which use frangible elements as safety “breakaway couplings”. Such safety “breakaway couplings” being intended to provide both a structural capacity for service-loads such as wind-loadings and a means of separating from the roadside device’s foundation such that the impacting vehicle’s driver and passengers not decelerate, due to the impact with the said roadside devices, greater than a given value.

[0018] In the case of highway sign structural supports—structural failure of said frangible elements due to fatigue-loads endanger the public due to a loss of said roadside devices’ intended utility in potential injury due to such roadside devices falling into the travelway and potential impacts by passing vehicles.

[0019] In the case of highway bridge railings, or bridge attachments to foundations, employing frangible anchor bolts or anchor bolts intended to structurally fail or give-way before the railing itself fails, isolating such hardware from fatigue loads is critical to the intended energy dissipations developed in such structural failures. Greater still is the need to dump out the shock loadings to such hardware, particularly where very high strength, tending to be of a more brittle nature, hardware is used.

[0020] A comparison of test data shows the present invention possesses unexpected improved properties that the present art does not have. The physical manifestation of the present invention centers around a “Fatigue Plate” on which frangible elements are structurally attached which in turn are structurally attached to a superstructure. Said Fatigue Plate is attached to a foundation such that loads applied to the superstructure, such as wind-loads is transmitted thru the frangible, and thru the fatigue plate to the foundation, and loadings such as earthquake-loadings is transmitted from the foundation thru the fatigue plate thru the frangibles and to the superstructure. Said “Fatigue Plate” element of the present invention has a geometry commensurate with the chosen plate material(s) composition.

[0022] A comparison of test data shows the present invention possesses unexpected improved properties that the present art does not have. The physical manifestation of the present invention centers around a “Fatigue Plate” on which frangible elements are structurally attached and in turn said Fatigue Plate is attached to a foundation. A Fatigue Plate of the present invention has a geometry, commensurate with the chosen plate material composition.

[0023] The original intent of my investigation of the COTS-NCHRP-350-4th Ed frangible items was to provide predetermined maximum lateral service load (PMLS) anchorage hardware for application of the present inventor’s FHWA Accepted For Use On The National Highway System (NCHS), Federal Findings Letter B123 NCHRP 350, Test Level 5 (L-5) of my light-weight, all-steel U.S. Department of Homeland Security (DHS) Qualified Anti-Terrorist Technology (QATT) Tractor-Trailer Truck Crash Barrier (TTTCB) specified as the TL-5 Bridge Rail Pay Item #25568.99M SISTEMA BRIDGE BARRIER SYSTEM (SISTEMA B 123) on the New York State Thruway Authority’s Tappan Zee Bridge Repair Project TNY 05-31B (D213533). Such predetermined maximum lateral service load anchorage hardware allows the use of TL-5 TTTCBs on weak or deteriorated highway bridge decks and rapid-deployment of TL-5 TTTCBs in DHS incident events with questionable in situ foundation conditions.

[0024] Due to the lack of industry recognized test standards for the above-mentioned application, a PMLS TL-5 TTTCB anchorage hardware configuration, I decided to utilize the government and industry recognized NCHRP 350 testing procedure for COTS-NCHRP-350-4th Ed frangible items as such resulting test data yields known maximum lateral load data that specific COTS-NCHRP-350-4th Ed frangible items will transmit to a foundation.

[0025] The initial test series involved three (3) sets of four (4) each COTS-NCHRP-350-4th Ed frangible items which were marked, for the double-blind testing, “M-Red”, “220” & “M-Blue”.

[0026] It became clear that while the set of possible compositions required to meet 4th Ed. Specifications was relatively large and that the set of possible compositions required to meet NCHRP 350 was relatively large, the subset of possible compositions required to meet both 4th Ed. & NCHRP 350 consisted of a relatively small overlap. Further, while 4th Ed. generally discusses roadside devices subjected to fatigue-type loads, 4th Ed.’s Section 12 which addresses roadway signing, unlike 4th Ed.’s specifications for other types of roadway structures, doesn’t specifically address fatigue-type loading. The abovementioned initial test series clearly showed that some of the frangibles were not fatigue-resistant.

[0027] The “M-Red” test results showed that this COTS-NCHRP-350-4th Ed frangible item apparently provided the structural strength to meet the structural requirements of 4th Ed. The same test results apparently show that “M-Red” exceeds the maximum allowable deceleration of FHWA and AASHTO required NCHRP 350 standards, “M-Blue”, while providing a deceleration well below the NCHRP 350 maximum allowable, was so “brittle” that its use is questionable when exposed to fatigue-type loadings such as high-speed passing truck traffic generated wind gust loadings.

[0028] This inventor conducted surveys of a number of State Departments of Transportation (DOT) and reviewed a
study by the Florida DOT which addressed a large number of “blow-downs.” Said surveys suggested structural fatigue failures of COTS-NCHRP-350-4th Ed flangible item supported roadside devices which are exposed to natural-wind gust, highway embankment and localized natural-wind accelerating features and vehicle-induced-gusting.

[0029] Vehicle-induced-gusting is a relatively recent recognized engineering issue as per AASHTO 4th Ed, Section 11.7.4 “Truck-Induced Gust”. Recognition of vehicle induced wind-gust by AASHTO begins with DeSantis and Haig “Unanticipated Loading Causes Highway Sign Failure,” Proceedings of ANSYS Convention, 1996 and more fully in NCHRP Report 469 (469), “Fatigue-Resistant Design of Cantilevered Sign, Sign, and Light Supports”, 2002, Section 2.2.2 Truck-Gust Pressure Measured . . .” with specific design guidelines at Section 3.1.1.5 and 3.2.1.5. The general issue of fatigue-type load investigation has a long history. An example of such older fatigue-type loading investigations are addressed in History Of Strength Of Materials, “With a brief account of the history of theory of elasticity and theory of structures”, by Stephen Timoshenko, Dover Publications, reprint 1983, originally published McGraw-Hill, 1953, page 167, “The Work of Wöhler (1819-1914) . . . .” The uniformity of the properties of materials is of vital importance in practical applications, and in an effort to get the uniformity, he drew up exacting specifications for the materials to be used . . .” (Wöhler) Page 169, “. . . for a fundamental study of the fatigue strength of steel, a large number of experiments were required, and Wöhler decided to use . . . smaller specimens which could be machined from circular bars of ½ in. in diameter. With the adoption of these smaller specimens, came the possibility of increasing the speed of the testing machine to about 40,000 revolutions per day. Thus many millions of cycles of stress could be applied to the specimens. Using several identical specimens with different forces applied at the ends and comparing the numbers of cycles required to produce fracture, Wöhler was able to draw some conclusion regarding the fatigue strength of his material. He did not use the so-called Wöhler’s curve in this analysis but he speaks about limiting stress (bruchgrenze). Wöhler recognized that, to eliminate the effect of sharp corners (FIG. 106a), [reproduced herein as FIG. 28] the fillets a should be introduced. Tests were made with the specimens shown in FIGS. 106b and 106c and it was found that specimens of uniform diameter exhibited the greater fatigue strength. It was also found that, in the case of the specimens of FIG. 106b, the fracture always occurred at the section mn where the sharp change in diameter is situated, so that by adding material to a shaft (corresponding to the increase in diameter at mn) we may make it weaker. Wöhler explains this in terms of irregularity of the stress distribution at the section mn and states that this weakening effect (of sharp corners) is of importance not only in axles, but it must be considered in the design of other kinds of . . . parts. Further experiments showed him that this weakening effect depends on the kind of material and that the reduction in strength produced by sharp corners varies from 25 to 33 percent. Again it was found that, if the sharp change in the cross section extends only a part of a circumference, as shown in FIGS. 107a and 107b, [reproduced herein as FIG. 29] the fatigue crack always begins at the sharp corner. The shaded portion of the cross section in FIG. 107b shows the coarse portion of the crack which can be seen after fracture.” Page 170, “The experiments done . . . involved complete reversal of the stresses. To obtain other kinds of cycles of stress, Wöhler designed and built another type of fatigue-testing machine in which rectangular specimens with simply supported ends were used. The varying deflections of the middle of the specimens were produced by an eccentric so that the stress in the most remote fiber from it (on the tension side) could be made to vary between its maximum value and zero or between the maximum value and some smaller tensile stress. Comparing the results obtained with this machine with those before with complete reversal of stresses, he found that the fracture always began at the tension side and that the magnitude of the maximum stress which the material could stand depended very much upon the difference between the maximum and the minimum of stress (i.e., upon the range of stress).” All the experiments showed that, for a given maximum stress, the number of cycles required to produce fracture diminished as the range of stresses was increased. From these tests, Wöhler concludes that in bridges of large span . . . a much higher allowable stress can be used than in axles or piston rods, where we have complete reversal of the stresses.” Page 172, “Wöhler concludes his work with an interesting discussion of working stresses. He recommends a safety factor of 2 for bars under constant central tensile stress so that the working stress is half of the ultimate strength of the material. In the case of cycles of stress, he again recommends a factor of safety of 2, which means that the working stress would be equal to one-half of the endurance limit. In both instances, it is assumed that the most unfavorable loading conditions are taken into consideration. At the joints of a structure, the working stresses should be much smaller to compensate for any irregularities in stress distribution. He calls for a careful investigation of these irregularities.” Page 173, “We see that these experiments were of a fundamental nature, and it can justly be said that scientific investigation in the field of fatigue of materials began with Wöhler’s work.”

[0030] Issued and application published patents revealing particular methods of meeting government required NCHRP 350 and 4th. Ed. specifications, while disclosing inadequacies in other potential methods, teach away from the present invention as they are silent on the issue of structural-fatigue-load-induced-failure and/or shock-load-induced-failure and their uniform expressed desire to structurally tie said frangible directly into very stiff, traditionally designed reinforced concrete foundations. That is, issued and application published patents’ scope rarely address the complete structural system of which frangibles are elements of, and when such patents mention the macro-structural system said frangibles reside in, they teach away from providing methods of enhancing frangibles’ resistance to structural fatigue or utilizing fatigue-resistant compositions to reduce installed costs of said macro-structural system.

[0031] The present invention significantly broadens the range disclosed in the prior art generally and that of present inventor’s issued U.S. Pat. Nos. 6,685,154 & 6,892,502 which address, in part, structural-fatigue-load-induced-failure and methods of providing commercially viable utilities to minimize such conditions.

OBJECT OF THE INTENTION

[0032] The principal object of the present invention is to provide flexure/amplitude-reducing/damping of fatigue
inducing, and/or shock loads such as natural wind & truck
gusts, and associated vortex shedding, shock from impacts,
and earthquake load regimes.

[0033] Another object of the present invention is to pro-
vide a reduced profile in relation to grade or ground-line,
minimizing potential snagging by impacting vehicles.

[0034] Another object of the present invention is to pro-
vide for factory-installation of frangible elements thereby
reducing potential for development of secondary stresses.
The present art of field installation of frangible elements
frequently accrues secondary stresses in said frangible ele-
ments due to the use of shims and such because of close
tolerances native to the present art frangible elements. The
Fatigue Plate element of the present invention allows for
factory installations of frangible couplings thereby remov-
ing the possibility of in the field installations which fre-
cently create secondary stresses in the final structural
configuration. Such secondary stresses result in less than
optimal breakaway characteristics and frequently result in
significant unequal loading of the frangible coupling sets.
The factory installation of the couplings on the Fatigue Plate
provides for ease of installation in the field.

[0035] Another object of the present invention is to pro-
vide that when a superstructure, such as when a portal-frame
or a post is shock-loaded below the center-of-mass of the
superstructure as in the specific case of a highway sign post
impacted by a vehicle the Fatigue Plate provides an initial
dynamic deflection drift of the superstructure in the direc-
tion of the load and thereby providing a load-time delay. Such
utility in the specific case of a highway sign post minimizes
the development of a vertical vector on the impacting
vehicle. This unexpected phenomenon was discovered dur-
ing the redaction to practice of the present inventor’s U.S.
Pat. No. 6,454,888 Roadway Energy Absorbing Impact
Attenuator. Minimizing or providing a negative vertical
vector to impacting vehicles significantly increases the sta-
bility of a crushing vehicle during impact and allows the
vehicle to track with stability following a said impact. The
present invention utilities, incorporates, this phenomenon.

[0036] Another object of the present invention is to pro-
vide stress-relieving/micro-crack-propagation-stop hole(s)
located in the Fatigue Plate element. Location of said hole(s)
being preferably, as taught by Wöhler, in line of fatigue
stress vectors.

[0037] An other object of the present invention is to pro-
vide for significantly greater tolerance variations in
attachment to foundation attachments thereby also minimiz-
ing development of associated secondary stresses. The
Fatigue Plate facilitates and is intended for use with the
present inventor’s U.S. Pat. Nos. 6,367,208; 6,409,433;
6,502,805 and 6,935,622 devices when such devices are
utilized as either laterally loaded foundations and/or super-
structures.

PRESENT ART

[0038] The present art is largely devoid of reference to
“breakaway couplings” or frangibles and providing means
and methods of fatigue and/or shock load mitigation. The
present art is addressed herein as follows: 1) The present art
is rich with references to structural attachments of super-
structures to foundations with significant numbers referenc-
ing “breakaway couplings” or frangibles. 2) The present art
has a few references to mitigating fatigue loads to typically
encountered structural hardware foundation attachment. 3)
That said, this inventor has found only one reference utiliz-
ing anchoring hardware intentionally designed to “break-
away” in which allowance for fatigue and/or shock loadings
are addressed. 4) The present invention resolves the prob-
lems identified during this inventor’s attempts to reduce to
practices the teachings of the referenced present art.

[0039] 1) The present art is rich with references to struc-
tural attachments of superstructures to foundations with
significant numbers referencing “breakaway couplings”
or frangibles. The following provide a broad review of such:

[0040] U.S. Pat. No. 68,886 issued Sep. 17, 1867 to King
(King), with particular interest at page 1, paragraph 6, and
page 1, paragraph 7. “The following is a description of the
construction and operation of my invention: A A’, FIG. 1, is
a pair of clamps, of the angular form shown, the foot of each
having a slit or notch, B B’, and bolt-holes C, FIG. 2, on the
upright portion.” . . . “The post is secured . . . by means of
the nuts of the screw-bolts . . . The posts can be readily
removed . . . by simply unscrewing the nuts, as seen in FIG.
4.” and page 1, paragraph 8, “I am aware that clamping
devices, singly and in pairs, are in common use for various
purposes; such, therefore, I do not lay claim to . . .” While
not referenced by post-1976 issued patents, derivatives of
the King device are evident and incorporated into most
present art “breakaway couplings” configurations.

[0041] U.S. Pat. No. 79,141 issued Jun. 23, 1868 to
McFarlin, (McFarlin) with particular interest at page 1,
paragraph 4, “I construct . . . posts . . . the lower end . . . set
firmly into a foundation . . . C represents a bolt, or it may be
a wooden pin, passing through the jaw and post, as shown
FIG. 1, in order to hold the . . . post “. . . upright . . . the
force . . . pressing against the . . . post “. . . will break the
pin, and allow the . . . post “. . . to fall over . . .”

[0042] U.S. Pat. No. 286,182 issued Apr. 25, 1883, to
Cunningham & Dickerson, and in particular, page 1 at line
10; page 1 at line 27; page 1 at line 32; page 1 at line 57;
page 1 at line 65; and page 2 at line 58.

[0043] U.S. Pat. No. 602,378 issued Apr. 12, 1898 to
Thomson, of interest at page 1 at line 8, and of particular
interest at page 1, line 76 “. . . I furthermore provide means
for . . . reducing the diameter of the bolts between the head
and the nut by a smooth cut . . . ” Also at page 1, line 90 and
also at page 1, line 95.

[0044] U.S. Pat. No. 1,481,187 issued to Clay (‘187), in
particular, page 1, line 14, “The prime feature . . . provide
means for retaining the post in substantially upright position
should the post be delivered a blow sufficient to break it
loose from its anchoring means thereby preventing the
breakage of . . . other parts connected with the post, . . . ”
and at page 1 at line 47. Also of interest at col. 2, line 14;
col. 2, line 25; col. 2, line 31, and at col. 2, line 41, “After
the central section of the bolt has thus been heated to a
temperature within the austenitic range, it is quickly cooled,
as by quenching in water, so that the central portion thereof
becomes hard and brittle.” and at col. 2, line 51.

[0045] U.S. Pat. No. 1,637,944 issued Aug. 2, 1927 to
Keller with particular interest at page 1, line 57, “ . . . as
shown in FIG. 3, each pin 5, as indicated at 8, has a breakable portion of reduced cross-sectional area . . . . See also, page 1 at line 87.

[0046] U.S. Pat. No. 1,669,700 issued May 15, 1928 to Egbert with interest at page 1, line 86, “Each of the bolts is provided between the flattened portion 15 and the outward end with a reduced portion 16 of predetermined cross-section.” Also of particular interest at page 2, line 37.

[0047] U.S. Pat. No. 1,674,565 issued Jun. 19, 1928 to Peterson, with particular interest at page 1, line 1, “This invention relates to new and useful improvements in signs and has for one of its objects to provide a sign in the form of a frame spring supported upon a sign post in a manner to vibrate under the influence of air current for the purpose of attracting attention thereto.”


[0049] U.S. Pat. No. 2,309,041 issued Jan. 19, 1943 to Booker & Hill, in particular, page 1 at col. 1, line 4; page 1, col. 1 at line 32; page 1, col. 2 at line 15 and page 1, col. 2 at line 27.


[0051] U.S. Pat. No. 2,638,368 (’368) issued May 12, 1953 to Weinberg, in particular, col. 1 at line 1; also col. 1 at line 16, “The principal object . . . . to provide a fragmentable bolt which, when used to connect two flanged elements together, will safeguard the other more expensive parts of the assembly by breaking under impact before damage is done to the rest of the structure.” Also, col. 1, line 38, “It is well known in the metallurgical art that when a heat hardenable material, such as a carbon steel, is hardened by heating and quenching, the tensile strength is increased but the material becomes harder and more brittle; the hardness increasing and the impact strength decreasing as the carbon content of the steel increases.” Also, col. 2, line 14, and in particular, col. 2, line 25, “However, in the case of severe impact, such as would result from a heavy vehicle colliding therewith, the shearing and bending stresses to which the bolt will be subjected would cause the hardened section thereof to break, thus releasing the bolted connection before any severe damage can be done to the connected parts.” Also see ‘368’s FIGS. 1 & 2.

[0052] U.S. Pat. No. 3,307,833 issued Mar. 7, 1969 to Muller & Bertram (’833) with interest at page 1, col. 1, line 24. Also at page 1, col. 1, line 40, “ . . . . the invention provides a safety . . . . a cast-iron shearing pin . . . .” Also at page 1, col. 2, line 59, “The shearing pin 22 is cast in one piece and provided with recesses 31 to save material.”

[0053] U.S. Pat. No. 3,349,531 issued to Watson and in particular see page 1, col. 1 at line 28.

[0054] U.S. Pat. No. 3,355,998 issued December, 1967, to Roemisch, see page 1, col. 1 at line 26; page 1, col. 1 at line 24, and in particular, page 3, col. 6 at line 38, “This fracturable member 76, as more clearly shown in FIG. 20, comprises a relatively soft metallic stud nut threaded at each of its ends 77 and provided centrally thereof with a relatively thin zone or breakneck 80. For purposes of installation into either the member 61 or the upper member 71, the fracturable member is also provided with wrench flats 81 and 82 on each side of the breakneck adapted to receive a wrench to permit the threads torqued into or out of their respective members.”

[0055] U.S. Pat. No. 3,499,630 issued Mar. 10, 1970 to Dashio (’630) with particular interest at page 1, col. 1, line 12 “Posts for individual use such as stop signs, street signs, street lighting, post and guard rail supports having a shearing coupling for joining to a ground support, the shearing coupling being provided with a shearing section shaped to permit a limited amount of bending movement while being sheared and which, upon impact, will provide spaced abutments which will shear off by impact and maintain the post in a vertical position, the shearing coupling being preferably of V-shape that extends inwardly from the outer periphery of the coupling to provide a reduced shearing area in the center of the coupling.” Also, page 1, col. 2, line 3, and in particular, page 1, col. 1, line 30, and page 1, col. 2, line 70, “The shearing coupling can be strengthened or weakened, depending upon its use, by increasing or decreasing the cross-sectional area of the shear point, which is at the reduced portion of the V coupling. The included angle of the V-shaped notch should be such as to provide sufficient clearance to permit the post to collapse on impact and transmit the impact force to the remaining unsheared portion through the juxtaposed flanges when they come in contact.”

[0056] U.S. Pat. No. 3,521,413 issued Jul. 21, 1970 to Scott & McClure, and in particular col. 1, line 34, “Rigidly mounted poles such as lamp posts or traffic standards, for example, adjacent traffic carrying surfaces of streets and highways present serious hazards to vehicles over which control has been lost. Particularly adjacent high-speed freeways and overland routes, collisions between such vehicles and rigidly mounted poles can result in serious injuries or fatalities as well as in extensive property damage. In recognition thereof, poles have been constructed which break away from their foundation when struck by a moving vehicle.” Also, col. 1, line 44, “Several such constructions are found in the prior art. In one of them, at least a lower portion of the post adjacent the foundation is constructed of a brittle concrete having a low impact resistance. Other designs utilize slip joints between the post and the foundation in which a horizontally acting force, such as a force from a striking vehicle, moves the post relative to its foundation until it becomes disengaged therefrom. It is also known to provide mounting screws or studs anchored in the foundation an undercut to weaken them and permit their severance when the post is struck by a vehicle. In the latter instance the studs are, of course, constructed so that they can withstand forces from the weight of the post, the label or sign mounted thereon as well as wind loads acting on the post. See also, col. 2, line 26, “ . . . . the present invention comprises elongated break-away members adapted to be secured to the upwardly projecting ends of studs anchored in the ground. The members have cross sectional areas which are capable of withstanding forces imparted upon them by the weight of the posts, signs or lamps mounted thereon as well as wind and ice loads acting on the post. The members are further constructed of a material having a relatively high tensile and compressive strength but a low impact strength so that a horizontally acting impact load will sever them and the pole breaks away from the foundation.” Also of interest, col. 2, line 37, “In the presently preferred form of this invention, the members are constructed of a heat treated steel. They are also made corrosion resistant, to prevent a gradual weakening of the reduced cross sectional areas and
possible failure of the members under static loads. They are, therefore, preferably constructed of a corrosion-resistant material or their outer surfaces are suitably coated such as by plating or hot dip galvanizing." Also, in particular, interest, col. 3, line 12, "A plurality of anchor studs 20 project from the upper end of the foundation block and have their projecting ends externally threaded (see FIG. 3). The lower end of the post 14 has a mounting flange 22 which includes mounting holes 24 (shown in FIG. 3) through which elongated break-away members 26 extend. An internally threaded sleeve 28 threadably engages the projecting end of the anchored studs and an externally threaded lower end 30 (best seen in FIG. 3) of the break-away members to thereby mount the lamp post on the foundation block." Also of interest at col. 3, line 22, "Referring to FIG. 3, in the presently preferred embodiment of this invention, each break-away member 26 includes an intermediate portion 32 which is recessed or grooved to reduce its cross sectional area."; col. 3, line 28, "Referring to FIGS. 1 through 3, the lamp pole is mounted on the foundation block by first securely threading a sleeve 28 onto the projecting end of each anchor bolt 20." Also, col. 3, line 64 and particularly at col. 5, line 74, "The reduced cross sectional area of the elongated members serves as an intentional weakening point at which the mounting of the lamp pole shall fail when subjected to dynamic loading from the impact of a moving vehicle when it strikes the pole." and col. 4 at line 4. Also of interest, col. 4, line 10, "Under dynamic loading, i.e., impact, maximum stresses in the member are cyclical and in increase in magnitude with decreased ductility or increased brittleness of the material. Thus, for a given cross sectional area, materials of high brittleness, such as hardened steel, for example, can withstand a lesser dynamic load, or have a lesser impact strength, than materials having a low brittleness, such as an annealed steel. At the same time, the hardening of materials, particularly steel, increases their tensile and compressive strengths and enables them to withstand static, that is non-dynamic loads of a much greater magnitude than relatively soft steels. And col. 4, line 22 "The combination of these two effects is highly desirable in break-away members 26. Their reduced cross sectional areas at portions 32 permits them to withstand the static loading from the weight of lamp pole 10, as well as from wind and ice loads when they are constructed of a heat-treatable material such as steel and have been heat treated to increase their strength. The greater hardness of the members, however, reduces their impact strength and enables them to withstand lesser impact loads than if they had not been heat treated. Thus, the reduced cross sectional areas of the members can be dimensioned so that they withstand the static loads to which they are subjected while failing under the impact of a vehicle striking lamp post 10." [0057] U.S. Pat. No. 3,552,698 issued Jan. 5, 1971 to Kinney, particularly, col. 1, line 4, "Traffic light standards, utility, and other poles, are plentifully used on, and along the shoulders of, roadways, and except for breaking off when the accidental impact is hard enough, they constitute the proverbial 'immovable object' in the path of a speeding vehicle, with disastrous results to the vehicle and its occupants, whether the pole breaks off or resists the impact applied." Also col. 1, line 11, "To reduce the ever-mounting toll of personal injury and property damage . . . ." and col. 2, line 30, "The total resistance to impact is, in part, a function of the mass of the pole and its supporting base 10. Therefore, other things being equal, the heavier the pole and its base, the greater its resistance to movement. Since the minimal mass of the pole and its support is fixed, it is necessary to minimize the mass of the devices by which the pole is attached, at minimum."

[0058] U.S. Pat. No. 3,572,223 (223) issued Mar. 23, 1971 to Vierregger and in particular, col. 2, line 60, and col. 5, line 1. See also ‘223’s FIGS. 1, 2, & 3.

[0059] U.S. Pat. No. 3,630,474 (474) issued Dec. 28, 1971 to Minor, particularly col. 1, line 12, and col. 1, line 23, "... it has increasingly apparent that there is a great need for a pole construction capable of providing only limited resistance to the impact of an automobile or other vehicle colliding with the pole. ... Specifically, it has been found that some installations of breakaway couplings have been subjected to substantial bending loads in addition to shear and tension loads. Failure due to bending loads on couplings of the type disclosed in the embodiment of this invention of the parent application have sometimes resulted in damage to the pole base support and to the anchor bolts in the foundation from which the couplings extend." Also, col. 1, line 57; col. 1, line 64 and col. 2, line 5, "Each of the elongated breakaway connector members 27 is hexagonal in cross-sectional configuration and is provided with the aforementioned circumferential recessed groove 34 extending about its periphery to provide an area 36 of weakened strength in comparison to the remainder of the elongated member and which separates the upper portion 29 from the lower portion 28." Also at col. 5, line 1. See also ‘474’s FIGS. 2 & 3.

[0060] U.S. Pat. No. 3,637,244 (244) issued Jan. 25, 1972 to Strizki, with particular interest at col. 1, line 10; also col. 1, line 17, "Various types of frangible posts or connections have been designed for this purpose heretofore. However, the frangible means employed in such an extent that the size or weight of the load which may be supported by the post is limited." Also col. 1, line 71, "Within the space between the lower surface 8 of the base 4 of the post and the upper surface of the foundation 12 are located breakaway coupling members 16. These members as shown are in the form of generally cylindrical pieces of material having a high tensile strength but possessing relatively little resistance to bending as compared to conventional fastening means heretofore used for mounting posts. A typical material adopted for use in forming the coupling member 16 is an alloy steel having a tensile yield strength of about 165,000 p.s.i. or more." Also, col. 2, line 6. See also ‘244’s FIG. 1.

[0061] U.S. Pat. No. 3,837,752 issued Sep. 24, 1974 to Shewchuk, with particular interest beginning col. 1, line 43; col. 1, line 50; col. 1, line 57, and col. 2, line 62, "The couplers 19 are preferably of round cylindrical form and are fabricated of high strength, low impact resistance material such as high grade cast iron. It is especially important that the inner core material be a high quality base for the internal screw threads at each end of the coupler. In addition the couplers have circumferential grooves 19A and 19B located near the coupler extremities as shown in FIG. 4." Also col. 3 at line 3, col. 3 at line 38, col. 3 at line 46, and col. 4 at line 4, "The maximum resistance of a coupler to bending fracture can be decreased by introducing circumferential grooves 19A and 19B with such geometry at the base of the groove as may be required to give the desired effect of stress concentration in bending. The distance from the groove to
the coupler extremity is approximately equal to or is slightly less than the inserted length of the bolt or stud in the coupler. This is significant because in this position the groove has little effect, other than to reduce the net cross section, on the axial load transfer capability between the inside bolt and the coupler since the inner thread governs as the critical axial stress concentration. At the same time the groove retains its effect as a stress concentrator for inducing bending fracture and, additionally, its position permits the maximum effective length of moment arm and, hence, maximum bending moment. The grooves are used, however, as required to give a better control on the bending strength.”

[0062] U.S. Pat. No. 3,951,556 (“556”) issued Apr. 20, 1976 to Strizki, with interest at col. 1, line 14, “A . . . sophisticated breakaway coupling assembly is shown and described in . . . U.S. Pat. No. 3,637,244. The construction of this patent has proven highly successful in extended tests by the New Jersey State Highway Department and has now been approved for use on New Jersey highways and elsewhere.” and at col. 1, line 21, “While the functioning of the device of said patent is very satisfactory it is found in practice that it presents many difficult problems in production, maintenance and installation. Thus, the numerous parts of the assembly are expensive to manufacture and require accurate casting and machining to close tolerances in order to assure proper functioning thereof. As pointed out in the example cited in said patent, a variation of as little as 0.01 inch in the positioning of the load concentrating element with respect to the breakaway coupling axes will significantly alter the operation of the assembly.” Also at col. 1, line 54, “In order to overcome these objections and limitations inherent in the construction of said U.S. Pat. No. 3,637,244, an improved assembly has been developed which utilizes the principals of operations of said patent . . . and providing a ‘fool-proof’ assembly wherein the proper positioning and acceptable place of the parts is assumed on all installations.”, and col. 3 at line 40. See also ’556’s FIG. 1.

[0063] U.S. Pat. No. 3,967,906 (“906”) issued Jul. 6, 1976 to Strizki at col. 5, line 35; col. 6, line 4; col. 12, line 35; col. 12, line 46; and col. 13, line 35. See also ’906’s FIG. 1.

[0064] U.S. Pat. No. 4,007,564 (“564”) issued Feb. 15, 1977 to Chisholm, with interest at col. 1, line 19, “Several varieties of breakaway couplings are known for the support of light standards, signs, parking meter, and the like. Some of these couplings or connectors are shown in U.S. Pat. Nos. 3,630,474; 3,572,223; 3,349,531 and 3,521,413, the teachings of which are herewith incorporated by reference therefor. Such breakaway connector or couplings desirably fail readily when the supported structure is subjected to lateral impact such as may be applied by a colliding automobile. However, the coupling must have substantial tensile and compressive strength. Yet such couplings desirably fail under the impact force in such a manner as to substantially reduce accident severity to motorists who are sufficiently unfortunate to be closely involved with the failure of such a coupling. Many breakaway coupling devices employ a shear or sliding mode of crack propagation; i.e., one surface of the ruptured coupling slides over another surface of the coupling during the impact failure process.” See also ’564’s FIGS. 1, 2, 3, 4, & 6.

[0065] U.S. Pat. No. 4,071,970 (“970”) issued to Strizki, with interest at col. 1, line 13; col. 1, line 24; col. 2, line 3; and in a related issue specific to the performance of a highway sign post application, col. 3, line 43. See also ’70’s FIG. 1.

[0066] U.S. Pat. No. 4,310,979 issued Jan. 19, 1982 to Bloom, with interest at col. 1, line 25, “In the case of a post that supports a sign . . . wind loading on the sign presents a problem. A low wind pressure, acting on a large sign area, puts a substantial amount of stress on the support posts. If conventional posts are designed to break under impact by a car, it is possible that the wind loading will generate enough force to break the posts. Conversely, designing the posts to withstand the wind loading makes them too strong to break under very high speed impacts; for low speed impacts they act as rigid barriers, and are the source of crash damage to the car and its occupants.” and at col. 1, line 58, “FIG. 1 shows the operation of a typical breakaway post when it is struck by a car. When the car strikes the post, the inertia of the sign causes it to remain approximately stationary while the post “breaks” at its intended point as described below. The lower portion of the post then deflects up, allowing the car to pass underneath. Thus the post does not pose a crash hazard to the car.”

[0067] U.S. Pat. No. 4,528,786 (“786”) issued to Diniz & Pappano, with interest at col. 1, line 12 and at col. 2, line 19. See also ’786’s FIG. 1.

[0068] U.S. Pat. No. 5,088,683 issued Feb. 18, 1992 to Briden, and particularly at col. 1, line 22, and at col. 1, line 26, “In 1985, AASHTO formulated new regulations for breakaway standards to be installed on federal highways. These regulations . . . require that the pole structures give way when struck with less impacting mass than that previously required. This lower impacting mass requirement has been caused by the construction of lighter cars. These new regulations become effective Jul. 1, 1990.” Also at col. 1, line 52, “Although the manufacturers of the prior art breakaway assemblies are attempting to redesign the prior art assemblies to meet the new specifications. This task is more difficult due to higher stress requirements due to taller poles, yet must fracture or release under lower impact mass. For example, in the use of the slip base, the standard may bend and place the slip bolts in tension preventing the slip base from slipping off the base flange.”

[0069] The above present art review provides the broad claims on which the more current present art refines. Said more current present art making reference to the above does not provide, and teaches away from, fatigue and/or shock load mitigation.

[0070] 2) The present art has a few references to mitigating fatigue loads to typically encountered structural hardware foundation attachment. One such present art, and the earliest found to date by this inventor is U.S. Pat. No. 1,334,519 issued Mar. 23, 1920 to Bushong, (Bushong) with interest at page 1, line 9; page 1, line 16 and with particular interest at page 1, line 21, “ . . . an improved reinforced concrete base construction in which vertical tower supporting rods are provided and arranged to take the direct weight of the tower frame, and are also provided with means for adjusting said tower frame into true vertical position.” Also at page 1, line 28, “It is a further object to provide these tower-supporting rods with an effective means for taking up the vibration transmitted thereto from the tower frame and thereby relieving the concrete material of any injurious
strains due to such vibration of the tower structure.” and at page 1, line 83. Also, page 1, line 95, “ . . . the weight of the tower frame is received directly upon the supporting rods 12, and in order that those vibrations of the tower frame which are imparted to said rods may be largely taken up without any appreciable injury to the concrete material, the latter is cored out around the upper ends of said rods to form the pockets 22 within which is tightly packed a quantity of composition material 24 of such a nature as to exert a shock-absorbing action about these particular portions of the rods where the vibrating tendency is most severe. The character of the composition material 24 should be such as to remain slightly plastic under all temperatures to which such tower constructions may be subjected.” Also, at page 2, line 14, “The manner of mounting the supporting rods and connecting the upper ends thereof to the tower frame provides a secure and reliable supporting structure whereby the transmission of the tower frame’s vibration may be effectively controlled, and the provision of the shock-absorbing material serves to practically eliminate any injurious strains to the concrete material of the base. The mode of securing the tower frame in position upon the supporting rods by the means of the adjusting and clamping nuts also affords a convenient and practical method of maintaining a proper vertical alignment of the tower frame.” Also with particular interest at page 2, line 39 “Claims: 1. In a tower construction, a concrete base having vertical supporting rods embedded therein and projecting above the top of the base, a composition of shock-absorbing material interposed between the upper portions of said rods and the surrounding concrete material, and a tower frame supported upon the upper projecting ends of said rods.” See also Bushong’s FIG. 1.

There are only five (5) issued U.S. patents referencing Bushong, issued after 1976, and as of this date, Bushong’s 1,334,519 does not appear as referenced in the USPTO’s Published Applications. Of the five (5), only U.S. Pat. No. 4,583,336, issued Apr. 22, 1986, to Shelangoskie, et al. explicitly references Bushong’s teachings of the use of “ . . . shock-absorbing material interposed between the . . . anchoring hardware . . . and the surrounding concrete material . . . ” of the superstructure’s concrete foundation.

Said five (5) issued U.S. patents are:

U.S. Pat. No. 4,583,336, issued Apr. 22, 1986, to Shelangoskie, et al., entitled “Joint of preformed concrete elements.” Shelangoskie, et al. clear incorporates Bushong’s teachings at col. 1, line 24, “The connector includes a metal pin, normally of a round or rectangular cross section and an elastic grommet around the metal pin. The metal pin and grommet are affixed within an end portion of a girder or within a column ledge, with a portion of the metal pin protruding outwardly of the girder or the column ledge, this outwardly protruding portion being affixed or slidably mounted within a beam or girder connected to the girder or ledge, respectively, depending on the type of loads anticipated.


U.S. Pat. No. 5,890,333, issued Apr. 6, 1999, to Boroviski, entitled “Concrete form.”


3) This inventor has found only one reference utilizing Bushong teachings of anchoring hardware and intentionally designed to “breakaway” in which allowance for fatigue and/or shock loadings are addressed, except one European issued patent. That is, the present art offers no implied or explicit teachings of Bushong in combination with the use of “breakaway couplings” or frangible to mitigate fatigue and/or shock loadings transmitted thru said “breakaway couplings” or frangible to or from superstructure or foundation, except a single European issued patent, ES2216093T, to Gasparetto-Stori and Serafini, (Stori & Serafin) published Oct. 16, 2004. The Stori & Serafin patent explicitly utilizes the 1920 teachings of Bushong’s “ . . . shock-absorbing material interconnected between the . . . anchoring hardware . . . and the surrounding concrete material . . . ” of the superstructure’s concrete foundation, and the 1868 teachings of McFarlin (U.S. Pat. No. 79,141) of utilizing “ . . . a bolt, or it may be a wooden pin, . . . in order to hold the . . . ” post “ . . . upright . . . ” the force . . . pressing against the . . . ” post “ . . . will break the pin, and allow the . . . ” post “ . . . to fall over . . . ”

The specific application of the Stori & Serafin patent, applying the teachings of McFarlin & Bushong, provides a highway crash barrier bridge railing in which both the shock of vehicle impact and explicitly designing the anchorage hardware to “breakaway” before structurally failing either the foundation (which in this specific case is a concrete highway bridge deck) and the bridge railing equipment. That is, the Stori & Serafin device specifically makes the anchor hardware the “weakest” structural element in the railing/anchorage/deck structural system while providing for full development of the intended strength of the said anchorage by providing a Bushong-type shock-load mitigation element.

Stori & Serafin teach of embedding the upper part of anchoring hardware in a “ . . . chamber . . . ” which “ . . . is filled with elastic material to obtain a better dissipation of the kinetic energy derived from the impact, thus reducing the mechanical stresses to which the anchor means are subjected.” Stori & Serafin’s FIG. 4 shows a “hollow chamber 23 . . . filled with an elastic element 11, in this case made of rubber, suitable to further dissipate the kinetic energy of the vehicles which hit the barrier and therefore to reduce the mechanical stresses on the anchor means 16.”

4) The present invention resolves the problems identified during this inventor’s attempts to reduce to practice the teachings of the referenced present art.

Structural failure of complex structural systems tend to occur due to combined load regimes. Such combined load regimes are transmitted from the points of application, thru a given complex structural system, to point(s) structurally tied to a “foundation” or location(s) of reaction(s) so transmitted. Application of loads to any complex structural
system causes physical displacement of individual structural elements making up said complex structural system. The path taken by applied loads traversing the structural system tend to initially get concentrated in the stiffer structural elements as the relatively more elastic elements deflect away from the load path. The present art “breakaway couplings” and frangibles utilize this to “concentrate” loads, applied to and traversing-thru a superstructure, just before attachment to a “foundation”, the intent being to predetermine the location “frangible” structural failure in the structural system, at the “breakaway coupling” or frangible. Problems with the present art have become evident due to two (2) load cases, fatigue & shock.

[0083] Present art “breakaway couplings” and other “necked-down” or “V-ed” at intermediate cross-sections are, in fact, exactly what Wöhler defined, in the 19th Century, as structural geometry highly susceptible to failure via fatigue load regimes.

[0084] Present art addressing shock loads as manifested by Bushong and Stori & Serafin have two have two (2) ‘reduction to practice’ problems. First, the COTS anchorage hardware specified in the Bushong and Stori & Serafin teachings is manufactured to minimum physical strength characteristics. Such hardware can have significant variations as to MAXIMUM physical strength characteristics. Second, the shock-absorbing material taught by Bushong and Stori & Serafin allows the COTS hardware to minimize shear loadings as the bolts, in the case of lateral loads, first bend and then go into tension. Such shock load regimes, when cycled, are in fact fatigue load-types.

PRESENT INVENTION

[0085] The present invention replaces the Bushong and Stori & Serafin taught shock-absorbing material with a “Mnesicles”-type bridging element which is allowed to dynamically deflect under fatigue and/or shock loadings. Said dynamic deflection delays the onset of load concentration in the “breakaway couplings” or frangibles which provide the only load-path between a given superstructure and said superstructure’s foundation. That is, the present invention stands between a superstructure and said superstructure’s foundation. The present invention provides a structural composite composed of a Mnesicles-bridging-element-with-frangible-elements and by designing the physical characteristics, relative to each other, the individual structural elements, of said structural composite, in concert provide a predetermined structural response to combined load regimes not addressed by the present art. Additionally, thru this inventor’s experiments, it has been shown that the present invention unexpectedly and significantly increased the subset range of steel alloy frangibles which provide the originally intended utility of “breakaway” and expected service loads such as wind-load and dead-load, with the Mnesicles-bridge element significantly increasing fatigue and/or shock load tolerance to said frangible elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0086] FIG. 1 is a representation, with modifications of the Maryland State Highway Administration (SHA) Standard Specification Sheet MD 821.06, depicting the SHA’s generic “Breakaway Base Support System For Highway Signs”. Said modifications are limited to location change of Sheet Title to upper left, elimination of notes #6 & 7 which relate to specific support post sizes and dimensions, as it is not intended for the present invention to be limited to such support post sizes, dimensions, the resultant geometries, and reaffirmation that the present invention is not intended to be limited to use as a breakaway base support system for highway signs.

[0087] FIG. 2 is a modification of FIG. 1 wherein “POST HINGE DETAIL” has been removed.

[0088] FIG. 3 depicts a FATIGUE PLATE, 1, providing flexure and damping, due in part to space, 3, of fatigue-loadings of supported equipment. Use of FATIGUE PLATE, 1, allows placement of foundation top below grade level, 2. Placement of foundation below grade allows significant tolerance of anchor bolts, 4, patterns and elevations as such anchor bolts may be cut-off after installation of FATIGUE PLATE, 1. FATIGUE PLATE eliminates need for SHA’S Breakaway Base Support System For Highway Signs use of shim plate and similar miscellaneous hardware which is required by SHA’S Breakaway Base Support System For Highway Signs to avoid development of secondary stresses in the frangible elements which reduces the utility of withstanding service loads such as wind-load and ice-load. FIG. 3 Plan View shows only a plan view of the FATIGUE PLATE, 1. FIG. 3 depicts an application of the present invention. Said FATIGUE PLATE, 1, utilizes that taught by the present inventor’s U.S. Pat. Nos. 6,685,154 (issued Feb. 3, 2004) and 6,892,502 (issued May 17, 2005) which directly address the recent rewrite of the AASHTO (American Association of State Highway and Transportation Officials) Design Code involving a shift in critical design load consideration to fatigue stress. Present invention provides SHA’S generic “Breakaway Base Support System For Highway Signs” types of structural applications with a construct that does not suffer the fatigue-load and/or shock-load weakness of the prior art designs while still able to transfer intended design loads. FIG. 3 shows a pattern circle for foundation anchor bolts outside the pattern circle of attachment of frangibles. This is not intended to limit the relationship of the two (2), or more pattern circles. For example, a foundation pattern may be located within the pattern circle of the frangibles. FIG. 3 also shows four (4) foundation anchors defining the pattern circle, it being understood that three (3) foundation and/or frangibles would also define a pattern circle.

[0089] FIG. 4 is a modification of FIG. 3, depicting replacement bracket, 5, of the SHA bracket attachment of support post to breakaway coupling frangibles, replacement bracket, 5, utilizing the teachings of King. Replacement bracket, 5 eliminates the need for three (3) different lengths of hardware bolts and the associated inventory carrying costs and potential confusion in field installation and maintenance activities. The full-scale test series conducted on this FATIGUE PLATE, 1, invention established the predetermined maximum lateral load for breakaway coupling frangibles of specific physical properties characteristics allowing for structurally efficiently designed brackets, 5.

[0090] FIG. 5 is a modification of FIG. 4, depicting elimination of the SHA bracket’s “Cap Screw Lock Washers”. Elimination of the SHA bracket’s “Cap Screw Lock Washers and the use of a radii, 6, (see FIG. 6) on the replacement bracket 5 allows the fabrication of said replace-
ment bracket from steel plate bent to the desired radius resulting in significant cost reduction in providing structural connection between support post and breakaway coupling frangible as the present SHA brackets are of expensive structural grade aluminum.

[0091] FIG. 6 is a modification of FIG. 5 depicting replacement of the SHA’s expensive “coupling bolt” (as per Maryland State Highway Administration Standard Specification Sheet MD 821.04, shown in part herein as FIG. 7) with a standard, straight shank, steel bolt, 7.

[0092] FIG. 7 is a modification of Maryland State Highway Administration Standard Specification Sheet MD 821.04, showing detail of SHA’s “coupling bolt”, 8.

[0093] FIG. 8 modifies FIG. 6 showing the use of both SHA’s “coupling bolt”, 8, as per FIG. 7, and standard, straight shank, steel bolt, 7, with sets of breakaway coupling frangibles. This combined use of standard bolt, 7, with SHA’s “coupling bolt”, 8, hardware is the product of new and unexpected results from this inventor’s full-scale test series, which due apparently to a first ever use of high-speed video, in such testing, captured images showing that SHA’s “coupling bolt” “rocks-away” from a lateral impact load (unlike when subjected to a service-load such as wind-load or ice-load) and does not become fully loaded until it is physically displaced. These new and unexpected test results allow the use of standard, straight shank, steel bolts, 7, which provided greater initial structural stiffness to the standard breakaway coupling frangible attached to said standard bolt, 7, causing said breakaway coupling frangible to carry the lateral impact load to its structural failure and then, due to its structural failure, transfer of the remaining lateral impact load to the “rocked-away” SHA’s “coupling bolt”. The effect of this new, mixed, hardware configuration is to allow either stronger individual breakaway coupling frangibles as they would not be loaded as a group or set but rather individually, or provide for lower, and therefore safer, lateral impact loads to achieve, in the case of Highway Signs as depicted in the SHA Standard Sheets, the breaking away of the support post, or both. Further, providing different dimensional SHA “coupling bolts” with associated bolt-hole and plate thicknesses will achieve a breakaway coupling grouping in which individual or subgroups structurally fail in predetermined sequences. Such sequential, kinetic-energy conversion, is outlined in black-letter and intent of the present inventor’s U.S. Pat. No. 6,454,488 issued Sep. 24, 2002, which reads in part (Abstract) “ . . . comprising a plurality of break-away . . . elements sequentially spaced to be sheared off by impact of a vehicle. Each . . . element individually absorbs and decelerates the impacting vehicle at a pre-determined rate that in multiple successive impacts slows the vehicle . . .”.

[0094] FIG. 9, modifies FIG. 8, depicting FATIGUE PLATE, 1, resting directly on a reinforced concrete foundation with a space, 3, maintained between the FATIGUE PLATE, 1, and said foundation, below the breakaway coupling grouping and thereby allowing the flexure of said FATIGUE PLATE when under the influence of loadings thru said breakaway coupling grouping. Providing direct contact between FATIGUE PLATE and foundation allows the use of anchor bolts, 4, as prestressing elements, and the FATIGUE PLATE as a backer plate, in the design and manufacture of said foundation, resulting in cost reductions normally associated with such prestress reinforced concrete items. Such a configuration allows the incorporation of the present inventor’s U.S. Pat. No. 6,409,433 issued Jun. 25, 2002 modified to incorporate the present invention’s anchor bolt, 4, pattern.

[0095] FIG. 10 is directly from the present inventor’s U.S. Pat. No. 6,409,433 issued Jun. 25, 2002, depicting a typical foundation of said invention.

[0096] FIG. 11 depicts the incorporation of the present inventor’s U.S. Pat. No. 6,409,433 issued Jun. 25, 2002, with the FATIGUE PLATE, 1.

[0097] FIG. 12 is directly from the present inventor’s U.S. Pat. No. 6,367,208 issued Apr. 9, 2002, depicting a typical application of said invention.

[0098] FIG. 13 depicts the incorporation of the present inventor’s U.S. Pat. No. 6,367,208 issued Apr. 9, 2002, with the FATIGUE PLATE, 1.

[0099] FIG. 14 depicts FIG. 6, with FATIGUE PLATE, 1, with multiple hole patterns for use with a range of standard or non-standard structural support elements. The extra hole patterns provide stress-relief and stop-crack utility, in addition to providing maintenance with versatile structural connection availability.

[0100] FIGS. 15 thru 23 are photos of factory-assembled SHA generic “Breakaway Base Support System For Highway Signs” with attached FATIGUE PLATES, 1.

[0101] FIG. 24 is a photo of a factory-assembled SHA generic “Breakaway Base Support System For Highway Signs” with attached FATIGUE PLATE, 1, with FATIGUE PLATE, 1, elevated and attached to foundation structure.

[0102] FIGS. 25 & 26 are after-impact photos of sheared breakaway coupling elements.

[0103] FIGS. 2700.00.00 thru 2700.14.47 are still-frames from high-speed video of one of the present inventor’s full-scale test. FIG. 2700.05.95 shows SHA’s “coupling bolt” “rocks-away” from a lateral impact load, as referenced in FIG. 8 description above. Impact object travels from right to left.


PREFERRED EMBODIMENT OF PRESENT INVENTION

[0105] The preferred embodiment of the present invention is a structural support system as depicted in FIG. 14, herein attached, consisting of a rectangular structural steel plate providing bridging between structural connections to a foundation and a superstructure via frangible hardware, where said plate’s deflection under expected service loads, including fatigue and/or shock loads does not physically make contact with said foundation and thereby providing flexure/amplitude-reducing/damping of fatigue and/or shock inducing loads.

EQUIVALENTS

[0106] Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention
described specifically herein. Such equivalents are intended to be encompassed in the scope of the following claims.

1. a structural support system attached to a structural element via frangible element providing a bridging connection to a foundation.
2. as in claim 1, where said bridging element is composed of steel.
3. as in claim 1, where said bridging element is composed of structural composites.
4. as in claim 1, where said structural support system is a plate.
5. as in claim 1, where said structural support system has holes not used in attachment to foundation or frangible element.
6. as in claim 1, where said structural support system provides resistance to prestressing a foundation.
7. as in claim 1, where said structural support system provides resistance to post-tensioning a foundation.
8. as in claim 1, where said structural support system provides resistance to prestressing and post-tensioning a foundation.
9. as in claim 1, where said foundation consists of reinforced concrete.
10. as in claim 1, where said foundation consists of structural steel.
11. as in claim 1, where said foundation consists of structural composites.
12. as in claim 1, where said foundation is driven into in-situ soil matrix.
13. as in claim 1, where multiples of said frangible element consist of different geometries.
14. as in claim 1, where multiples of said frangible element consist of different materials.
15. as in claim 1, where multiples of said frangible element consist of different structural characteristics.
16. as in claim 1, wherein said structural support system presents a rounded surface minimizing snag potential to an impacting vehicle.
17. as in claim 1, two or more structural hardware fasteners providing structural connections from a structural element to frangible elements, wherein two or more of said fasteners consist of different geometries.
18. as in claim 1, two or more structural hardware fasteners providing structural connections from a structural element to frangible elements, wherein two or more of said fasteners consist of different materials.
19. as in claim 1, two or more structural hardware fasteners providing structural connections from a structural element to frangible elements, wherein two or more of said fasteners consist of different structural characteristics.
20. as in claim 1, wherein a reduced profile in relation to grade or ground-line, minimizes potential snagging by impacting vehicles.

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