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Title: SHEAR AND BENDING REINFORCEMENTS OF COUPLING BEAMS OF COUPLED SHEAR WALLS

Abstract: The innovation is related to coupling beams of coupled (hollow) shear walls which consist of diagonal reinforcements which act as a main carrier system, vertical reinforcements, horizontal reinforcements, joints, connection points and additional areas due to hollows like doors, windows, transition systems or left for functional reasons.
DESCRIPTION
SHEAR AND BENDING REINFORCEMENTS OF COUPLING BEAMS OF COUPLED SHEAR WALLS

TECHNICAL FIELD
The Innovation is related to coupling beams of coupled shear walls which consist of diagonal reinforcements which act as a main carrier system, vertical reinforcements, horizontal reinforcements, joints areas, connection points and additional areas.

PRIOR TECHNIQUE

In carrier systems in which the shear walls are used, coupled shear (hollow) walls are formed due to the gaps which are left for functional reasons such as doors, windows or transitional systems. These types of shear walls are named as coupled shear walls or shear walls with coupling beams. The positioning of hollows together with their numbers and sizes along the wall affect the activity of construction and the distribution of internal forces in coupling beams and shear walls. When the hollows which are left in shear walls are relatively smaller than the size of walls, the effect of hollows are neglected and the system is known to be a shear wall without hollow. However when the hollows left in shear walls are relatively bigger, their effect on the system is taken into account and alternatively the system is designed and constructed as coupled shear (hollow) wall. In this type of constructions the positioning of hollows in shear walls and the effects of hollows on structural system should be taken into consideration. When the coupling beams and coupled shear walls are designed appropriately, they can act ductile enough.

Shear walls and coupled shear walls systems are frequently found in buildings. Higher shear walls and coupled shear walls which have higher rigidity according to columns are preferred mainly for compensation of horizontal forces such as earthquake and wind. Coupled shear walls come into existence when hollows like doors, windows, corridor e.t.c are left on structural walls. These types of systems which are special types of structural wall systems are named as coupled shear wall.
When the coupling beams of coupled shear walls in multi storey reinforced concrete buildings are designed and constructed in a ductile way, they act more ductile than shear walls without hollows.

Due to the effect of the lateral forces on the coupled shear wall system; while shear forces and bending moments occur in coupling beams; axial forces, shear forces and bending moments occur in coupled shear walls. Because of horizontal forces which affect coupled shear wall system, the overturning moments which is formed in the system is carried by two separate force groups. These consist of bending moments which are formed in shear wall system and reaction moments which are formed by reverse marked, equal valued axial pair of forces in shear walls. The intensity of axial forces in pair of shear walls depend on the ability of coupling beam to transfer the shear force which is formed on them without losing its capacity. When the rigidity of coupling beams increases, the walls would work together effectively. On the contrary, the normal force in walls will increase due to the shear force in coupling beam. The shear force coming to coupling beams increase, with the decrease of bending moments to the walls and the increase of rigidity of coupling beam.

The main aim of coupling beams is to maintain the transfer of shear forces between coupled shear walls that are formed from horizontal forces affecting the system. Coupling beams are exposed to reverse cyclic reversed loading. In coupled shear walls, earthquake effects is primarily concentrated on coupling beams. In cases where these effects exceed the capacity in coupling beams; bending damages are observed at the bases of the walls. According to scientific experiments that were made on coupled shear walls, it was found that the conventional beam details had a negative effect on activity of the system. Short span coupling beams equipped with classic flat reinforcements and stirrups, become weak due to the tension and pulling forces that occur without reaching their bending capacity of the cross sections. In short span coupling beams, equipped with classic flat reinforcements and stirrups; even though the stirrups are properly arranged and shearing capacity is well maintained by increasing rate of shearing capacity, short span coupling beams do not show functional activity due to weakening of adherence under reversed cyclic
loading, joining of bending cracks on two sides and power exhaust in shearing forces at the edges.

Scientific experiments indicated that reinforcements placed direction of diagonal especially in short and deep coupling beams showed positive results in terms of functional activity. The details of diagonally reinforced coupling beams have been involved in many current regulations such as Turkish Earthquake Regulation (ABYYHY 2007), European Earthquake Regulations (Eurocode8 2004), and U.S.A Concrete Institution (ACI 2008) e.t.c. Joining of this kind of diagonal reinforcements to concrete in coupled shear walls is important. By writing balance of a coupling beam you can easily find sufficient reinforcement force and area required. When seismic force affects coupling beam to coupled shear wall connection system in one direction, cross reinforcement bars which shows extension and lifts pulling force stays in concrete pressure area as seismic force changes its direction. If there is elastic extension exceeding limit in reinforcement, it carries most of pressure even without enclosing the cracks in concrete.

In the coupling beam shear wall systems, coupling beams with shear walls are aimed to work together. According to the Turkish Earthquake Regulation (ABYYHY 2007), if these two equations provided below balance, special shearing reinforcement which will be placed in coupling beam will be determined by methods which have scientific proof or cross reinforcements will be used so as to compensate bending moment and shearing force formed by coupling beam.

\[ f_n \leq 3xh_k \]
\[ V_d > 1.5xb_wxdxf_d \]

In the formula above;
- \( i_n \): free open space range between surfaces of structural walls of coupling beam,
- \( h_k \): coupling beam height,
- \( b_w \): coupling beam body width,
- \( d \): coupling beam utility height,
- \( f_d \): concrete design pulling endurance.
According to Turkish Earthquake Regulation (ABYYHY 2007), the total reinforcement area clustered by each of the cross reinforcement will be determined according to the formula below.

\[ A_{sd} = \frac{V_d}{2f_{yd} \sin \gamma} \]

In this formula:
- \( A_{sd} \): Total area clustered by each of the cross reinforcement
- \( V_d \): Shearing force calculated under companion of earthquake forces and horizontal forces multiplied with force coefficients,
- \( f_{yd} \): Longitudinal yield strength of the reinforcement,
- \( \gamma \): The angle made by cross reinforcement bars with horizontal.

According to the Turkish Earthquake regulation (ABYYHY 2007), at least four reinforcement's bars must be ready in cross cluster reinforcements in order to compensate shearing force and bending moment formed by it in coupling beam. Similarly these reinforcements must be lengthened at least one and a half times more into the shear wall. Reinforcement's bars will be surrounded with special earthquake stirrups of diameters not less than 8 mm with the distance range not exceed 100 mm and will not larger than 8 times diameter of cross reinforcement bar. In addition to cross reinforcements, minimum amount of stirrup and horizontal reinforcement will be placed in coupling beam.

According to the European Earthquake Regulation (Eurocode8 2004), in order to compensate the seismic effects reinforcements, both equations given below must be balanced and will be used throughout each of diagonal under conditions provided below.

\[ I < 3 \times h \]

\[ V_{Ed} > b_w \cdot d \cdot f_{yd} \]

In the formula above:
- \( I \): free open space range between surfaces of structural walls of coupling beam,
- \( h \): coupling beam height,
- \( V_{Ed} \): design shear force in coupling beam
- \( b_w \): coupling beam thickness,
- \( d \): coupling beam utility height,
According to Eurocode 8 2004, the equation below must be balanced in coupling beams having cross reinforcement bars:

\[ V_{Ed} = 2 \times A_{si} \times f_{yd} \times \sin \alpha \]

In the formula above:
- \( V_{Ed} \): design shear force in coupling beam
- \( A_{si} \): total area of each diagonal direction to reinforcements in coupling beam
- \( f_{yd} \): longitudinal yield strength of the reinforcement,
- \( \alpha \): the angle made by cross reinforcements used in coupling beam with horizontal

b) Diagonal reinforcements must be equipped in such a way that their wideness are at least 0.5 x \( b_w \) as part of column.

c) Stirrups must be used in order to prevent the buckling of longitudinal reinforcements which are equipped like columns.

d) Vertical and horizontal reinforcements must be placed on both sides of coupling beam and minimum conditions emphasized in European Earthquake Regulation (Eurocode 2004) must be maintained.

Cross reinforcements surrounded by tight stirrups must be constructed in a way to surround each other and to pass in the middle of coupling beam as illustrated in the regulations. Similarly these cross reinforcements must be installed at edges of shear walls. Construction of such cross reinforcements is nearly impossible. The density in cross equipments in coupling beams and at edges of the shear wall; has generated many difficult problems in preparation of reinforcements, placing in between them, arrangement and installation. Moreover, it causes cross equipments to be different from the original structure emphasized in project thus making the construction impossible in most cases.

As a result of the construction technique, firstly construction of coupled shear walls require constructing shear wall's edges which are surrounded with tight stirrups and which have densely longitudinal reinforcements followed by construction of cross reinforcements surrounded with tight stirrups installed at edges shear walls and anchor them to the shear walls body. Due to the impossibility in construction and installation of cross reinforcements passing through each other with tight stirrups,
these type of cross reinforcements find no place when it comes to the application. These cross reinforcements are not practical for placement and installation under conditions of construction site.

Different types of coupling beam reinforcements were presented to literature due to the difficulties in application and installation of cross reinforcements. As per coupling beam reinforcement literature; after placing H profile horizontally into the coupling beam and anchoring bearing walls, a new composite beam type is established. Here H profile is installed horizontally to the coupling beam as a single piece. Steel plates are welded to H profile in order to delay the profile's bending and corrugation in coupling beam. This Steel H profile produced as a single piece also create problems in installation and anchoring.

Prefabricated girders (precast) were presented as coupling beams to the literature before. Tie girders and their reinforcements are prepared as precast in other words poured concrete coupling beam is brought to construction site. Anchor reinforcements are stretched from coupling beam reinforcements. Precast beams are prepared under factory conditions and they are delivered to the construction site, installed reinforcements are inserted into coupled shear walls and placed then coupled shear wall is poured and single piece system is created. In such case, reinforcements emerged from precast coupling beams, create problems when they are placed to bearing walls.

Previously, in literature H profiles as coupling beam reinforcements are welded to each other in a cross style then with this one piece cross reinforcement was created and tested. At the ends of H profile, which will remain into coupled shear walls, cut parts are welded in order to extend the size of anchor. Installing and placing H profiles, which are welded to each other as one piece, into wall and coupling beam is nearly impossible.

**BRIEF SUMMARY OF THE INNOVATION**

The Innovation is related to coupling beams of coupled shear walls (hollow) which consist of diagonal reinforcements which act as a main carrier system, vertical reinforcements, horizontal reinforcements, joints, connection points and additional areas due to hollows like doors, windows, transition systems or left for functional reasons.
Coupling beam reinforcements which presented in previous literature are constructed as monolithic (single piece). It is not practical to apply monolithic cross reinforcements due to their difficulties in installation and anchoring into shear wall. So, with this proposal using steel structural elements part system (L profiles, U profiles, T profiles, H profiles, box profiles, pipe profiles or L, U, I, T, H, box and pipe segment metal sheet) double row diagonal and the horizontal steel members winded with welded stirrups a new type of reinforcement for coupling beams is published. Each part system can be manufactured in a factory environment or at the construction site. The horizontal and diagonal reinforcements for coupling beam is fragmented so that it is becoming very easy to assemble. The steel structural elements that staying in coupling beams and the steel structural elements that will stay in shear wall will be manufactured as fragment and will be installed in site. In this way, the diagonal reinforcement for coupling beams can be practiced in construction site and brought to a condition that can be built.

DESCRIPTION OF FIGURES

Figure 1. Assembly view of the coupling beam to the coupled shear wall
Figure 2. Perspective assembly view of the coupling beam to the coupled shear wall
Figure 3. Assembly view of the coupling beam
Figure 4. Perspective view of the coupling beam
Figure 5. Exploded views of the coupling beam
Figure 6. General view of the diagonal reinforcement
Figure 7. General view of the welded beam stirrups

Part numbers on figures with their corresponding names are provided below.

1. Coupling beam profile
2. Cross reinforcement
   2.1. Anchor connection part
   2.2. Diagonal arm
3. Horizontal reinforcement
4. Horizontal anchor arm

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5. Connection plate
6. Welded beam stirrups

DETAILED DESCRIPTION OF THE INNOVATION

The invention has at least four coupling beam profile (1) in between at least two inserted anchor connection part (2.1) and the diagonal arm (2.2) comprised of cross reinforcement (2), the cross reinforcement (2) comprises of connection plate (5) on its connection point, on the cross reinforcement (2) connection point the horizontal reinforcement (3) joined to the connection plate, the horizontal reinforcement (3) and the anchor connection part (2.1) that connects the horizontal anchor arm (4) and welded beam stirrup (6) holding together all the equipment that is composed of parts and sections.

Coupling beam profiles (1) between the cross reinforcement (2) and horizontal reinforcement (3) should be built in two rows parallel to each other and must be connected together with welded beam stirrup (6).

The known technique of cross beam reinforcement must have at least four pieces of equipment and these reinforcement should be extended at least one and a half times the length into the shear wall. The reinforcement should be wrapped with special seismic stirrup. On right and left side of coupling beam the boundary zones of the shear walls are exist. The boundary zone of the Shear wall reinforced with dense vertical rebar surrounded by stirrup with frequent intervals. Cross beam reinforcement wrapped with stirrups; with dense reinforcement ratio to shear wall anchors the cross reinforcement is becoming almost impossible be installed.

In coupling beam of coupled (hollow) shear walls, seismic effects and the effects of wind as well as horizontal forces and additional vertical loads, ground effect, temperature variations, and such burden arises from the force of the coupling beams in the negative effects are minimized for my studies, cross reinforcement and horizontal reinforcement parallel to each other in two rows of steel structural elements (L profiles, profiles, I profiles, T profiles, H profiles, tubing and pipe profiles or L, U, I, T, H, box and pipe cross-section metal sheets) and held together by designed as vertical reinforcement welded beam stirrups (6) and steel structural members, including screws, bolts, high strength bolts, riveted, intelligent screwed,
welding and similar fastening elements by adopting connection enabling new 
accessories have been revealed. 
Rectangle, square, ellipse or circle-shaped connection plate (5), at least two anchor 
connection part (2.1) and diagonal-arm (2.2) section consisting of cross 
reinforcement (2); with bolt, rivets, high strength bolt, screws, smart screws, welding 
and other connecting methods resemble. Two parallel sequence coupling beam 
profile (1) to be constructed, cross reinforcement (2), the connecting plate (5), the 
horizontal reinforcement (3), the horizontal anchoring bar (4) composed of parts of 
steel structural components L, U, I, H, T, box section profiles and pipes, or L, U, I, H, 
T, box-section and tubes can be manufactured from sheet metal. 
Cross reinforcement (2), diagonal arms (2.2) junction section of the connection plate 
(5) and horizontal reinforcement (3) with screws, smart screws, bolt, high strength 
bolt, rivet, weld and similar assembly elements between them formed by combining 
the steel structural elements together will be constructed in two parallel rows. These 
structural elements to be constructed in two rows welded beam stirrup (6) will be 
fixed to each other. Connection plate (5) should be designed in a way it can 
accommodate the loads so that appropriate width, height and thickness which might 
be in the form of square, rectangular, oval and circular. On Connection plate (5) the 
proper holes or channels should be left for coupling beam cross reinforcement 
connection. Prepared in accordance with the project steel structural elements length, 
width and thickness of the project and often are placed at appropriate intervals. 
While Coupling beam (hollow) stay within the shear wall, the anchor providing 
horizontal reinforcement (3) and the cross reinforcement (2) anchor connection part 
(2.1) that connects the horizontal anchor arms (4) are combined with the mounting 
element like screws, self-tapping screws, bolt, high strength bolt, rivet, welding and 
others alike. 
The coupling beams and the connection system to the shear wall which has been 
constructed in this way by establishing standard code can provide resistance to the 
effect due to seismic forces or load exposure which is much safer for the people 
living in the building and economic structures can be constructed. 

In our invention of coupling beam of a coupled shear wall, the described parts and 
accessories with the system in the event of the creation is more affordable, which can
be built faster and more secure, industrial building systems can be created. These days, coupling beams are constructed like columns the dense anchors made of vertical rebar as a result of cross reinforcement with frequent stirups passing through end boundary zone of the shear wall. With frequent intervals of stirrups built like clingy column reinforcement placement in the construction phase of the cross reinforcement, concrete pouring and compression stages are faced with huge problems.

In our innovation we saw that in coupling beam without dense reinforcement installation, simple construction and costs minimized, safe industrial buildings can be built. Also provided that the resistance to horizontal and vertical force reinforcement preparation, placing reinforcement, concrete pouring and compression phase problems are eliminated.
CLAIMS

1. Coupling beam of coupled shear wall, its features; characterized with coupling beam profile (1), cross reinforcement (2), horizontal reinforcement (3), horizontal anchor arm (4), connection plate (5) and welded beam stirrup (6) parts.

2. In claim 1 wherein said cross reinforcement (2), its features; characterized with anchor attachment part (2.1) and the diagonal arm (2.2) parts.

3. In claim 1 wherein said coupling beam profile (1), cross reinforcement (2), horizontal reinforcement (3), horizontal anchor arm (4), its features; characterized with L profiles, U profiles, I profiles, T-profiles, H-beams, box profiles and pipes profiles or L, U, I, T, H, box and pipe section being made of sheets metals.

4. In claim 1 wherein said cross reinforcement (2), horizontal reinforcement (3), horizontal anchor arm (4) and connection plate (5), its features; characterized with at least two rows parallel to each other for construction.

5. In claim 1 wherein said horizontal anchor arm (4), its features; characterized with anchor part built within shear wall providing attachment for the coupling beam.

6. In claim 1 wherein said welded beam stirrup (6), its features; characterized in that, parallel to each other at least in two rows built cross reinforcement (2), horizontal reinforcement (3), horizontal anchor arm (4) and connection plate (5) and each set consisting a channel which parts fit in.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. E04H9/02 E04C5/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E04H E04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category* Citation of document, with indication, where appropriate, of the relevant passages Relevant to claim No.

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figure 3
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figures 1-3, 6
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figures 2, 3, 5, 9
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* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

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“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“Z” document member of the same patent family

Date of the actual completion of the international search

22 September 2014

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X See patent family annex.

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Further documents are listed in the continuation of Box C.
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