DESCRIPTION

Variable and Fixed Joints-Nodes for the interconnection of tubes or rods or beams of any cross section, length or material, for the formation of mesh constructions of any shape size or strength.

This invention refers to a variety of variable or fixed angle mechanical joints-nodes which are used to interconnect between them tubes or rods or beams of any cross section or size or material, in order to form in an easy economical and fast way mesh constructions of any shape size or strength, for use mainly in the building and construction industry, in architectural designs and in decorative structures, but also in many other cases like modular assemblies of educational games, modular bridges and roofing constructions of any shape or size for immediate covering of special needs in disaster areas, greenhouses, scaffolding, sheds, towers, etc.

Mesh constructions with any kind of materials and any size of tubes or rods or beams of any cross section, have ALWAYS been used by humans in all kinds of applications. In ALL cases the PRIMARY question and concern has always been HOW to interconnect the tubes or rods or beams, i.e. the straight parts of the mesh construction, between them. The usual up to now practice has been to simply study each mesh construction separately case by case and find a solution according to the material used, the cross section of each straight part and the size and strength requirements of the mesh.

In WODEN meshes the usual practice is to get the ends of each straight part specially carved either by technicians on site during construction or by some industrial process and to complete the construction by fixing the sections with nails and/or screws and/or gluing, either between themselves or by specially designed joints-nodes.

In METALIC meshes again the ends of each straight section are specially treated / shaped in a similar philosophy, e.g. they are flattened by compression and holes are drilled holes in the flat areas or flanges are welded for fixing with screws or welded directly or fixed with some form of notch / holder or some special form of node specifically designed for each case. In some applications for decorative purposes, this node has the form of a ball which has holes at the necessary positions for the required angles of the straight parts, which are interconnected by screwing or welding or securing somehow in the holes of the ball joints-nodes.

Under the above level of technical knowledge and expertise there is no possibility for mass production of standardised joints-nodes or straight sections for a wide range of applications, with primary target the lowering of cost for the production of the straight sections and the parts of the nodes and the cost and time for the construction of the mesh. With the present level of expertise it is necessary to use specific methods in each case for shaping the ends of the straight parts and for designing the respective nodes for the different lengths, cross sections and kinds of straight parts and nodes. Some kind of standardization -mainly for decorative meshes- does exist in the case of interconnection with balls with holes or with flattening and drilling the ends of straight sections, but also in these cases there is no significant lowering of cost and time. In the case of meshes of large size and heavy construction for use as strength elements e.g. in buildings, for bridges, for roofing and coverings in general, etc, it is necessary to construct in the factory the complete mesh or large sections of it with high cost special design and manufacturing methods for each case and there is need for time consuming and high cost procedures to transport the mesh and/or its sections on site for erection / assembly with heavy lifting machinery.

The object of the present invention is the design of series-varieties of standard components for the assembly of joints-nodes with variable-self adjusting angles which can be used for the construction of meshes of any shape size or strength, as well as the design of series-varieties of standard joints-nodes with fixed angles which can be used for the construction of meshes of fixed shape and any size or strength according to the fixed nodes used. The above standardised nodes those of variable angles assembled from standard components or those of fixed angles, can be produced with standardized series production industrial methods in any size and from any material, according to the requirements of any specific application and in large quantities for significant reduction of cost of products.

The interconnection of the straight parts with the variable or fixed nodes can be effected with various methods according to the application, the material of the nodes and of the straight parts and the strength requirements of the mesh.

In the case of tubes used as of straight parts, there can be opposite threading at the two ends with respective threading at the holes of the nodes and the straight parts can be screwed-in at both ends by turning in one direction and screwed-out by turning in the opposite direction.

Another method for interconnection of straight parts of any cross section with the nodes, is to fit tight the straight part in the respective position of the node and to secure it with a through bolt-plug and/or welding.

The advantages of this invention are the following:

1. Significant reductions of production costs of the nodes and the straight parts and for the final mesh constructions, due to the standardization of the components and the methods of construction-assembly of the meshes, by production of a variety of standard nodes for any kind of applications, with standardized series production industrial methods.
2. Significant reduction of construction time for the meshes by simplifying and standardizing the construction procedures.
3. Extensive possibilities for fast designing of mesh constructions of any shape and size and strength.
4. Possibilities of assembly of mesh constructions at the sites of installations with non specialized workforce with minimal needs for lifting equipment.
5 Possibilities of use of standard tubes rods beams from the general trade as straight parts for the meshes at the site of erection, with parallel use of simple portable equipment for the cutting of the straight parts at the required lengths followed by the drilling or opening the threading at the ends of the parts and/or the welding, according to the chosen method of interconnection.

The invention will be described below with reference to the attached drawings, where the various series of the different components nodes and indicative mesh constructions are illustrated in detail. All the different drawings of components and nodes are individually numbered and for easier recognition of all parts and models, each part is given a descriptive code name according to its use and operational characteristics. The meaning of each code name is given below.

Figure 1 illustrates all the components of the **VAR**iable node for construction of meshes of two dimensions **2D** and **S**ingle side with code name **VAR-2D-S**. The two identical **S**mall moving arms (3) -**S**mall **ARM = S-ARM**- are inserted inside the rectangular holes existing on the two identical **B**ig moving arms (4) -**B**ig **ARM = B-ARM**- and all four arms are interconnected by the **PLUG** (1) which is secured at the end with the **NUT** (2).

Figure 2 illustrates four views of the above node VAR-2D-S fully assembled. The angle X which is formed between the two big moving arms (4) which have the code name **B-ARM-2D-S**, can vary and self-adjust within the limits provided by the design with free turning of the two big arms on the PLUG (1). The angle Y which is formed between one big moving arm (4) and the associated small moving arm (3), can vary and self-adjust with free turning of the small arm (3) within the limits allowed by the rectangular hole on the associated big moving arm (4), which has the length of the sides in the direction of movement larger than the length of the side of the square small arm.

The code name of the small moving arm (3) **S-ARM**, is the same for all types of variable nodes, because this component is the same for all types of variable nodes, with the exception of different size nodes off course and the opposite threading in the holes for the screwing interconnection method as explained below. The same is valid also for the **PLUG** and the **NUT**.

Figure 3 illustrates two views and two cut sections of the small (3) and big (4) moving arms.

Figure 4 illustrates two views of a straight mesh construction (20) with variable node type VAR-2D-S and tube straight parts (21). The two nodes in enlargement -details J, K- illustrate the method of interconnection of the tube straight parts by screwing with opposite threading at the two ends of each part and respective threading in the arms. The ends of the straight parts that screw-in with **R**ight turning have code letter **R** (22) and the ends that screw-in with **L**eft turning have code letter **L** (23). Respectively, the small and big arms that are used in each node have suitable threading to accept right or left turning screwing depending on the position of the node and have the respective code name **S-ARM-L** for **L**eft turn screwing-in or **S-ARM-R** for **R**ight turn και **B-ARM-2D-S-L** for **L**eft turning or **B-ARM-2D-S-R** for **R**ight turning. The general principle for the interconnection method by screwing with opposite threading is that there are two types of assembled nodes in one mesh, one that has the ONE small arm with LEFT threading and ALL other arms with RIGHT threading and another node with the opposite situation, i.e. ONE small arm with RIGHT threading and ALL other arms with LEFT threading.

Figure 5 illustrates one view of a flat plane mesh construction of three dimensions (24), which is formed from a number of straight mesh constructions (20) illustrated in Fig. 4 interconnected in parallel one next to the other with tube parts (25). This interconnection of identical parallel 2 dimension meshes can be again effected by opposite threading at the two ends of each straight tube part (25) and respective opposite threading at the two ends of the PLUG (1). This method of interconnection is illustrated in the enlarged detail K of the interconnected three dimensional mesh.

Figure 6 illustrates two views of a two dimensional bent mesh construction (26) with variable node VAR-2D-S and tube straight parts (21).

Figure 7 illustrates one view of a bent plane mesh construction (27) of three dimensions, which is formed from a number of bent mesh constructions (26) illustrated in Fig. 6 interconnected in parallel one next to the other with tube parts (25). This interconnection can again be effected by opposite threading at the ends of the tube parts (25) and respective opposite threading at the two ends of the PLUG (1), as for the flat plain mesh of Fig. 5.

Figure 8 illustrates one view of a two dimensional mesh construction (28) of special shape with variable node VAR-2D-S and straight tube parts (21). With the variable node it is possible to construct two or three dimensional meshes of any shape within the limitations enforced by the angles X and Y.

Figure 9 illustrates one view of one more two dimensional mesh construction (29) of special shape. Each of the above two dimensional meshes of special shape as well as any other of any other special shape can be interconnected in parallel with straight tube parts (25) one next to the other, for construction of respective three dimensional meshes.

Figure 10 illustrates all the components of the variable node with code name **VAR-2D-D** for construction of meshes of two dimensions **2D** and **D**ouble side. The two identical small moving arms (3) are inserted inside the rectangular holes existing on the two identical big moving arms (5) with code name **B-ARM-2D-D** and all four arms are interconnected by the PLUG (1) which is secured at the end with the NUT (2), with the same inventive principles as for the variable node with code name VAR-2D-S above.

Figure 11 illustrates 4 views of the above node VAR-2D-D fully assembled. The angles X and Y can vary as in the case of variable node VAR-2D-S 1 above.

Figure 12 illustrates three views of the big moving arm (5) with code name B-ARM-2D-D.

Figure 13 illustrates two views of a straight mesh construction (30) with variable node type VAR-2D-D and tube straight parts (21). The two nodes in enlargement -details A, B- illustrate the method of interconnection of the tube straight parts by screwing with opposite threading at the two ends of each part and respective threading in the arms, with the same inventive principles as for the variable node with code name VAR-2D-S, Fig. 4 above.

Figure 14 illustrates a view of a flat plane mesh construction of three dimensions (31) with variable node VAR-2D-D, which is formed from a number of straight mesh constructions (30), illustrated in Fig. 13, interconnected in parallel one next to the other with tube parts (25). This interconnection of identical parallel 2 dimension meshes can be again effected by opposite threading at the two ends of each straight tube part (25) and respective opposite threading at the two ends of the PLUG (1), with the same inventive principles as for the variable node with code name VAR-2D-S, Fig. 5 above. This method of interconnection is illustrated in the enlarged detail H of the three dimensional mesh.

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Figure 15 illustrates two views of a two dimensional bent mesh construction (32) with variable node VAR-2D-D and tube straight parts (21). The enlarged node -detail J- illustrates the bent taken by the arms to form the said bent mesh.

Figure 16 illustrates all the components of the variable node with code name **VAR-3D-S** for construction of meshes of three dimensions **3D** and **S**ingle side. The two identical small moving arms (3) are inserted inside the rectangular holes existing on the two identical big moving arms (6) with code name **B-ARM-3D-S** and all four arms are interconnected by the PLUG (1) which is secured at the end with the NUT (2), with the same inventive principles as for the variable nodes with code names VAR-2D-S and VAR-2D-D above.

Figure 17 illustrates 4 views of the above node VAR-3D-S fully assembled. The angles X and Y can vary as in the cases of variable nodes VAR-2D-S and VAR-2D-D above.

Figure 18 illustrates three views of the big moving arm (6) with code name B-ARM-3D-S.

Figure 19 illustrates one view of a three dimensional straight mesh construction (33) with variable node type VAR-3D-S and tube straight parts (21). The two nodes in enlargement -details H, G- illustrate the method of interconnection of the tube straight parts (21) by screwing with opposite threading at the two ends of each part and respective threading in the arms, with the same inventive principles as for the variable nodes with code names VAR-2D-S and VAR-2D-D above.

Figure 20 illustrates a view of a flat plane mesh construction of three dimensions (34) with variable node VAR-3D-S, which is formed from a number of straight 3 dimensional mesh constructions (33), illustrated in Fig. 19, interconnected in parallel one next to the other with tube parts (25). This interconnection of identical parallel three dimensional meshes can be again effected by opposite threading at the two ends of each straight tube part (25) and respective opposite threading at the two ends of the PLUG (1), with the same inventive principles as for the variable nodes with code names VAR-2D-S and VAR-2D-D above.

Figure 21 illustrates two views of a three dimensional bent mesh construction (35) with variable node VAR-3D-S and tube straight parts (21). The enlarged nodes

-details F, E- illustrate the bent taken by the arms to form the said bent mesh.

Figure 22 illustrates one view of a 3 dimensional bent plane mesh construction (36), which is formed from two bent mesh constructions (35) iillustrated in Fig. 21, interconnected in parallel one next to the other with tube parts (25). This interconnection can again be effected by opposite threading at the ends of the tube parts (25) and respective opposite threading at the two ends of the PLUG (1), with the same inventive principles as for the variable nodes with code names VAR-2D-S and VAR-2D-D above.

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Figure 23 illustrates one view of a 3 dimensional bent plane mesh construction (37) with variable node VAR-3D-S, which is formed from two bent mesh constructions (35) of Fig. 21 interconnected directly one next to the other.

Figure 24 illustrates one view of a 3 dimensional bent plane mesh construction (38) with variable node VAR-3D-S, which is formed from four bent mesh constructions (35) of Fig. 21 interconnected directly one next to the other.

Figure 25 illustrates all the components of the variable node with code name **VAR-3D-D** for construction of meshes of three dimensions **3D** and **D**ouble side. The two identical small moving arms (3) are inserted inside the rectangular holes existing on the two identical big moving arms (7) with code name **B-ARM-3D-D** and all four arms are interconnected by the PLUG (1) which is secured at the end with the NUT (2), with the same inventive principles as for the variable nodes with code names VAR-2D-S, VAR-2D-D and VAR-3D-S above.

Figure 26 illustrates 3 views of the above node VAR-3D-D fully assembled. The angles X and Y can vary as in the cases of variable nodes VAR-2D-S, VAR-2D-D and VAR-3D-S above.

Figure 27 illustrates three views of the big moving arm (7) with code name B-ARM-3D-D.

Figure 28 illustrates one view of a three dimensional straight mesh construction (39) with variable node type VAR-3D-D and tube straight parts (21). The two nodes in enlargement -details B, C- illustrate the method of interconnection with the same inventive principles as for the variable nodes with code names VAR-2D-S, VAR-2D-D and VAR-3D-S above.

Figure 29 illustrates one view of a combined 3 dimensional straight mesh construction (40) with variable node VAR-3D-D, which is formed from the previous mesh construction (39) of Fig. 28, interconnected directly with two more identical meshes one next to the other in one direction, with additional interconnection through the PLUGS (1) with parallel parts (25), for even higher strength. Bent combined mesh constructions are off course also possible with the variable node VAR-3D-D.

In the case of mesh constructions of specified shape, either for permanent installation or for removable / re-assembled installation, the angles X and Y of the nodes are pre-selected and specific and it is not necessary to have the possibility of varying these angles on the nodes. In these cases the nodes can be **FIX**ed, i.e. **FIX** nodes, provided that the required quantities of **FIX** nodes justify the cost of moulds for mass production with the specific angles X and Y, so that the final cost of the specific **FIX** node can be lower than the respective cost of a **VAR**iable node of equal size and strength. The fixed nodes described below have been designed with the same inventive principles as for the variable nodes above, in order to achieve the same targets and advantages as with the variable nodes and additionally even more reduction of cost and simplicity of the final mesh construction procedures.

One **FIX** node can be **S**traight with the angles X and Y = 90 and 45 degrees respectively for construction of straight meshes or **B**ent with different X angles smaller than 90 degrees and respectively different Y angles, for construction of bent meshes of specific shape.

Figure 30 illustrates four views of the **FIX** node with code name **FIX-2D-S-S** (8) for mesh constructions of two dimensions -**2D**-, **S**ingle side, **S**traight shape.

Figure 31 illustrates four views of the **FIX** node with code name **FIX-2D-D-S** (9) for mesh constructions of two dimensions -**2D**-, **D**ouble side, **S**traight shape.

Figure 32 illustrates four views of the **FIX** node with code name **FIX-3D-S-S** (10) for mesh constructions of three dimensions -**3D**-, **S**ingle side, **S**traight shape.

Figure 33 illustrates four views of the **FIX** node with code name **FIX-3D-D-S** (11) for mesh constructions of three dimensions -**3D**-, **D**ouble side, **S**traight shape.

Figure 34 illustrates 2 views of the **B**ent **FIX** node with code name **FIX-2D-S-Bxy** (12), for mesh constructions of two dimensions -**2D**-, **S**ingle side, **B**ent shape, with specific x and y angles. In each specific model, the letters x and y are replaced by the actual degrees of the two angles.

Figure 35 illustrates 2 views of the **B**ent **FIX** node with code name **FIX-2D-D-Bxy** (13), for mesh constructions of two dimensions -**2D**-, **D**ouble side, **B**ent shape, with specific x and y angles.

The ends of the node arms in the above two Fig. 34 and 35, have been designed with a square outside cross section to demonstrate this alternative possibility, which allows for respective square cross section hollow beams to be used as straight parts for the mesh construction instead of tubes, by fitting tightly outside the square ends of the arms.

Figure 36 illustrates 2 views of the **B**ent **FIX** node with code name **FIX-3D-S-Bxy** (14), for mesh constructions of three dimensions -**3D**-, **S**ingle side, **B**ent shape, with specific x and y angles.

Figure 37 illustrates 2 views of the **B**ent **FIX** node with code name **FIX-3D-D-Bxy** (15), for mesh constructions of three dimensions -**3D**-, **D**ouble side, **B**ent shape, with specific x and y angles.

Figure 38 illustrates three views-sections (16) (17) (18) which demonstrate the interconnection methods of straight parts (21) (25) INSIDE the receptacles-holes in the arms of the various variable or fixed nodes and one view-section (19) which demonstrates the respective interconnection methods of HOLLOW BEAM straight parts (21) (25) of any cross section OUTSIDE the receptacles of the arms. The first view (16) illustrates the interconnection of TUBE straight parts by screwing-in, the second view (17) the interconnection of straight parts of any cross section with through pin-bolt and the third view (18) the interconnection of straight parts of any cross section with welding. In the first two cases (16) (17) it is possible to use welding additionally for even higher strength. The fourth view (19) illustrates the interconnection of hollow beams with through pin-bolt and / or welding. The straight part can have any cross section that fits tight inside or outside the respective receptacle of the arm and is interconnected with through pin-bolt and / or welding. The cross section of the receptacle of the arm does not have to be exactly the same as the respective cross section of the straight part, as long as one fits tight into the other. For example a straight part with a star shape cross section can fit tight inside or outside a round receptacle and be interconnected-secured with through pin-bolt and / or welding. The various shapes of cross section of the straight parts can have wide application in light mesh constructions from aluminium or other suitable materials, e.g. plastics or glass, for decorations.

In the case of through pin-bolt, the arms of the nodes can be produced directly with ready holes, so that in the field of construction there will only be need to drill holes in the tube or rectangular or any other profile straight parts will common portable drilling equipment.

The variable and fixed nodes of all types and sizes can be combined between themselves in one mesh construction very easily, according to any special requirements of any building or architectural or decorative or artistic design.

Two big moving arms (4) or (5) or (6) or (7) of DIFFERENT types of nodes but of the SAME SIZE, can be assembled together with two same size small moving arms (3) on one same size PLUG (1), thus forming **C**ombined **VAR**iable nodes for use in very special applications-constructions. Therefore, the following can be

1st: big arm (4) with big arm (5) or with (6) or with (7),
2nd: big arm (5) with big arm (6) or with (7)
3rd: big arm (6) with big arm (7)
The code names of the combined nodes created from these combinations are the following:
From big arms (4) and (5): CVAR-2D-S/2D-D, illustrated in Fig. 39 (41)
From big arms (4) and (6): CVAR-2D-S/3D-S, illustrated in Fig. 39 (42)
From big arms (4) and (7): CVAR-2D-S/3D-D, illustrated in Fig. 39 (43)
From big arms (5) and (6): CVAR-2D-D/3D-S, illustrated in Fig. 40 (44)
From big arms (5) and (7): CVAR-2D-D/3D-D, illustrated in Fig. 40 (45)
From big arms (6) and (7); CVAR-3D-S/3D-D, illustrated in Fig. 40 (46)

In general the present invention provides to the Constructor, Civil Engineer, Architect, Decorator, even to the Sculptor-Artist and Children or Students for playing or training, ENDLESS possibilities for designing mesh constructions for every feasible application with the lower possible general cost and the greatest easiness from any other available technical method.