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Equitable Regular Total Semi-µ Strong (Weak) Edge Domination in Intuitionistic Fuzzy Graph

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Abstract. In this paper, the new kind of parameter Regular total semi - µ strong (weak) edge domination number in an intuitionistic fuzzy graph is defined and established the parametric conditions. Another new kind of parameter an equitable regular total semi - µ strong (weak) edge domination number is defined and established the parametric conditions. The properties of Regular total semi - µ strong (weak) edge domination number and an equitable regular total semi - µ strong (weak) edge domination number domination number are discussed.

Keywords: Dominating set, total semi - µ strong (weak) edge domination set, Regular total semi - µ strong (weak) edge domination set, equitable regular total semi - µ strong (weak) edge domination set, equitable regular total semi - µ strong (weak) edge domination number.

AMS Mathematics Subject Classification (2010): 03E72, 05C69, 05C72, 05C76

1. Introduction

In the year 2003, Nagoor Gani and Basheer Ahamed [8] investigated Order and Size in fuzzy graph. In 2010, Nagoor Gani and Begum[10] investigated Degree, Order and Size of an Intuitionistic Fuzzy Graph. In the year 2016, Karunambigai and Bhuvaneswari [7], investigated Degree in Intuitionistic fuzzy graph. In 2010, Parvathi and Tamizhendhi [11] introduced Domination in intuitionistic fuzzy graph. In the year 2014, Dharmalingam and Rani [2,3], investigated the concepts of Equitable Domination in Fuzzy graphs. In the year 1991, Kulli and Patwari [6] investigated the concepts of on the total edge domination number of a graph In the year 2008, NagoorGani and Prasannadevi [9] proposed Edge domination and independence in fuzzy graph. In 2012, Jayalakshmi et al. [4] introduced total strong (weak) domination in fuzzy graph. In 2016, Jayalakshmi et al. [5] introduced total semi - µ strong (weak) domination in intuitionistic fuzzy graph. In this paper, we introduced Equitable Regular Total semi - µ strong (weak) domination in intuitionistic fuzzy graph and some parametric conditions are established as a new concept.

2. Preliminaries

In this section, some basic definitions are discussed.

Definition 2.1. [7] Let G = (V, E) be an **intuitionistic fuzzy graph (IFG)** where V={$v_1,v_2,\ldots,v_n$}. Then,

i. $\mu_1 : V \to [0,1]$ and $\gamma_1 : V \to [0,1]$ respectively denote the degree of membership and non-membership of the element $v_i \in V$ and $0 \le \mu_1(v_i) + \gamma_1(v_i) \le 1$ for every $v_i \in V$.

ii. $E \subset V \times V$ where $\mu_2 : V \times V \to [0,1]$ and $\gamma_2 : V \times V \to [0,1]$ are such that $\mu_2(v_i, v_j) \le \min\{\mu_1(v_i), \mu_1(v_j)\}$, $\gamma_2(v_i, v_j) \le \max\{\gamma_1(v_i), \gamma_1(v_j)\}$ and $0 \le \mu_2(v_i, v_j) + \gamma_2(v_i, v_j) \le 1$ for every $(v_i, v_j) \in E$.

Definition 2.2.[10] Let G = (V, E) be an IFG, Then the **cardinality of G** is defined to be

$$|G| = \left| \sum_{V_i \in V} \left[\frac{(1 + \mu_1(v_i) - \gamma_1(v_i))}{2} \right] + \sum_{V_i \in V} \left[\frac{(1 + \mu_2(v_i, v_j) - \gamma_2(v_i, v_j))}{2} \right] \right|$$

Definition 2.3. [10] The **fuzzy vertex cardinality** of G is defined by

$$p = |V| = \left| \sum_{V_i \in V} \left[\frac{(1 + \mu_1(v_i) - \gamma_1(v_i))}{2} \right] \right| \text{ for all } v_i \in V$$

Definition 2.4. [10] The **fuzzy edge cardinality o**f G is defined by

$$q = |E| = \left| \sum_{V_i \in V} \left[\frac{(1 + \mu_2(v_i, v_j) - \gamma_2(v_i, v_j))}{2} \right] \right| \text{ for all } (v_i, v_j) \in E.$$

Definition 2.5. [8]

Let G = <V,E> be an IFG. Then the **order** of G is defined to be O(G) = $(O_\mu(G), O_\gamma(G))$ where $O_\mu(G) = \sum_{v_i \in V} \mu_1(v_i)$ and $O_\gamma(G) = \sum_{v_i \in V} \gamma_1(v_i)$

Definition 2.6. [8] The **Size** of G is defined to be S(G) = $(S_\mu(G), S_\gamma(G))$ where $S_\mu(G) = \sum_{i \ne j} \mu_2(v_i, v_j)$ and $S_\gamma(G) = \sum_{i \ne j} \gamma_2(v_i, v_j)$

Definition 2.7. [8] Let G = $((\mu_1, \gamma_1), (\mu_2, \gamma_2))$ be an IFG. The μ-degree of a vertex v_i is $d_\mu(v_i) = \sum_{(v_i, v_j) \in E} \mu_2(v_i, v_j)$. The γ-degree of a vertex v_i is $d_\gamma(v_i) = \sum_{(v_i, v_j) \in E} \gamma_2(v_i, v_j)$.

The **degree of a vertex** is $d(v_i) = [\sum_{(v_i,v_j)\in E} \mu_2(v_i, v_j), \sum_{(v_i,v_j)\in E} \gamma_2(v_i, v_j)]$ and $\mu_2(v_i, v_j) = \gamma_2(v_i, v_j) = 0$ for $v_iv_j \notin E$.
The **minimum degree** of G is $\delta(G) = \min\{d_\mu(v_i), d_\gamma(v_i) | v_i \in V\}$.
The **maximum degree** of G is $\Delta(G) = \max\{d_\mu(v_i), d_\gamma(v_i) | v_i \in V\}$

Definition 2.8. [8] The **degree of a vertex** v in an IFG G = (V, E) is defined to be sum of the weights of the strong edges incident at v. It is denoted by W(G).

Definition 2.9. [11] A subset D of V is called a **dominating set in an IFG** G if for every $v \in V-D$, there exists $u \in D$ such that $u,v \in E(G)$.

Definition 2.10. [11] A dominating set D of an IFG is said to be **minimal dominating set** if no proper subset of D is a dominating set.

Definition 2.11. [7] A strong (weak) dominating set T_μ of an intuitionistic fuzzy graph is said to be **semi-μ strong (weak) dominating set** if $\mu_2(v_i, v_j) = \min(\mu_1(v_i), \mu_1(v_j))$ for every v_i and v_j.

Definition 2.12. [5] Let G be an intuitionistic fuzzy Graph. A semi - μ strong (weak) dominating set T_μ of an IFG is said to be **total semi - μ strong (weak) dominating set of intuitionistic fuzzy graph G** if $d_N(u) \geq d_N(v)$ for all $u \in T_\mu$, $v \in V$.

Definition 2.13. [5] A total semi - μ strong (weak) dominating set T_μ of an intuitionistic fuzzy graph G is called **minimal total semi - μ strong (weak) dominating set** of G if $v \in T_\mu$, $T_\mu - \{v\}$ is not a total semi - μ strong (weak) dominating set of G.

Definition 2.14. [5] The minimum fuzzy cardinality among all minimum total semi - μ strong (weak) intuitionistic fuzzy dominating set in G is called **total semi - μ strong (weak) dominating number of G** is denoted by $\gamma_{T_\mu}(G)$.

Definition 2.15. The **degree of effective edge** of e_i is the sum of the membership value of the effective edge incident on e_i, denoted by $d_E(e_i)$.

Definition 2.16. Let G be an intuitionistic fuzzy graph. The edge set T_e is said to be a **total edge dominating set** if for every edge in G dominates atleast one edge of T_e.

Definition 2.17. Let G be an intuitionistic fuzzy graph. The edge set T_e is said to be **total strong (weak) edge dominating set of G** if

i $d_N(e_i) \geq d_N(e_j)$ for all $e_i \in T_e$, $e_j \in E$

ii T_e is a total edge dominating set.

Definition 2.18. A total strong (weak) dominating set T_e of an intuitionistic fuzzy graph G is called **minimal total strong (weak) edge dominating set** of G if v $\in T_e$, T_e- {v} is not total strong (weak) edge dominating set of G.

Theorem 2.19. In an IFG, $W_{Te}(G) \leq O_{Te}(G) \leq S_{Te}(G)$

Proof: Let G be an intuitionistic fuzzy graph. Sum of fuzzy vertex cardinality of an intuitionistic fuzzy graph but need not be a minimum of weighted total strong (weak) edge domination IFG of G. Therefore, $W_{Te}(G) \leq O_{Te}(G)$. $S_{Te}(G)$ be a size of total strong (weak) edge dominating set but need not be a minimum of sum of fuzzy vertex cardinality of total strong (weak) edge dominating set, then $O_{Te}(G) \leq S_{Te}(G)$.

Hence , $W_{Te}(G) \leq O_{Te}(G) \leq S_{Te}(G)$.

Theorem 2.20. In an IFG, $W_{Te}(G) \leq \delta_{Te}(G) \leq \Delta_{Te}(G)$

Proof: Let G be an intuitionistic fuzzy graph. $\delta_{Te}(G)$ is a minimum degree of total strong (weak) edge domination of IFG but need not be a minimum of weighted total strong (weak) edge domination in IFG, then $W_{Te}(G) \leq \delta_{Te}(G)$. $\Delta_{Te}(G)$ is a maximum degree of total strong (weak) edge domination of IFG but need not minimum of minimum degree of total strong (weak) edge domination of IFG. Therefore, $\delta_{Te}(G) \leq \Delta_{Te}(G)$.

Hence , $W_{Te}(G) \leq \delta_{Te}(G) \leq \Delta_{Te}(G)$.

3. Main results

Regular total semi - µ strong (weak) edge dominating set of an IFG

In this section, Regular total semi - µ strong (weak) edge dominating number of an intuitionistic fuzzy graph is introduced and its parametric conditions are established. Let us consider p ≤ q throughout the paper.

Definition 3.1. A total semi - µ strong (weak) edge dominating set eRT_μ of a graph G is a **regular total semi - µ strong (weak) edge dominating set** if all the edges have same degree.

Definition 3.2. A regular total semi - µ strong (weak) edge dominating set eRT_μ of a intuitionistic fuzzy graph G is called **minimal regular total semi - µ strong (weak) edge dominating set** of G, if v $\in eRT_\mu$, eRT_μ - {v} is not a regular total semi - µ strong (weak) edge dominating set of G.

Definition 3.3. The minimum fuzzy cardinality among all minimal regular total semi - µ strong (weak) edge dominating set is called **regular total semi - µ strong (weak) edge dominating set** and its regular total semi - µ strong (weak) edge domination number is denoted by $\gamma_{eRT_\mu}(G)$.

Theorem 3.4. In an IFG, $\gamma_{eRT_\mu}(G) \le p \le q$

Proof: Let G be an IFG. γ_{eRT_μ} be a regular total semi - µ strong (weak) edge domination number of an IFG. p be a sum of fuzzy vertex cardinality of an IFG G but need be a minimum of a regular total semi - µ strong (weak) edge domination number of an IFG. γ_{eRT_μ} be a regular total semi - µ strong (weak) edge domination number of an IFG is less than or equal to sum of fuzzy vertex cardinality of an IFG. That is, $\gamma_{eRT_\mu}(G) \le p$. q be a sum of fuzzy edge cardinality of a regular total semi - µ strong (weak) edge domination of an IFG but need not be a minimum of sum of fuzzy vertex cardinality of a regular total semi - µ strong (weak) edge domination of an IFG of G. Then, sum of fuzzy vertex cardinality is less than or equal to sum of edge cardinality of a regular total semi - µ strong (weak) edge domination of an IFG G. That is, $p \le q$.

Hence, $\gamma_{eRT_\mu}(G) \le p \le q$.

Theorem 3.5. In an IFG of G, $W_{eRT_\mu}(G) \le O_{eRT_\mu}(G) \le S_{eRT_\mu}(G)$

Proof: Let G be an IFG. γ_{eRT_μ} be a regular total semi - µ strong (weak) edge domination number of an IFG.

$O_{eRT_\mu}(G)$ be an order of a regular total semi - µ strong (weak) edge domination of an IFG of G but need not be a minimum of a weighted regular total semi - µ strong (weak) edge domination of an IFG. Then, weighted regular total semi - µ strong (weak) edge domination of an IFG of G is less than or equal to order of an IFG. That is, $W_{eRT_\mu}(G) \le O_{eRT_\mu}(G)$. $S_{eRT_\mu}(G)$ be a size of a regular total semi - µ strong (weak) edge domination of an IFG but need not be a minimum of an order of an edge IFG of G. Then, an order of a regular total semi - µ strong (weak) edge domination of an IFG is less than or equal to size of an edge IFG. That is, $O_{eRT_\mu}(G) \le S_{eRT_\mu}(G)$.

Hence, $W_{eRT_\mu}(G) \le O_{eRT_\mu}(G) \le S_{eRT_\mu}(G)$

Theorem 3.6. For an IFG, $\gamma_{eRT_\mu}(G) \ge \left|\frac{p-q}{2}\right|$

Proof: Let G be an IFG. γ_{eRT_μ} be a regular total semi - µ strong (weak) edge domination number of an IFG. Let p be a sum of fuzzy vertex cardinality of an IFG G. Let q be a sum of fuzzy edge cardinality of an IFG G.

$\left|\frac{p-q}{2}\right|$ be a fuzzy vertices but need not be a maximum of a regular total semi - µ strong (weak) edge domination number of an IFG of G. Then, a regular total semi - µ strong (weak) edge domination number of an IFG of G is greater than or equal to $\left|\frac{p-q}{2}\right|$ fuzzy vertices. Hence, $\gamma_{eRT_{\mu}}(G) \geq \left|\frac{p-q}{2}\right|$

Example 3.7. Let G be an intuitionistic fuzzy graph. Let γ_{eR_T} be a regular total strong (weak) edge domination number of G.

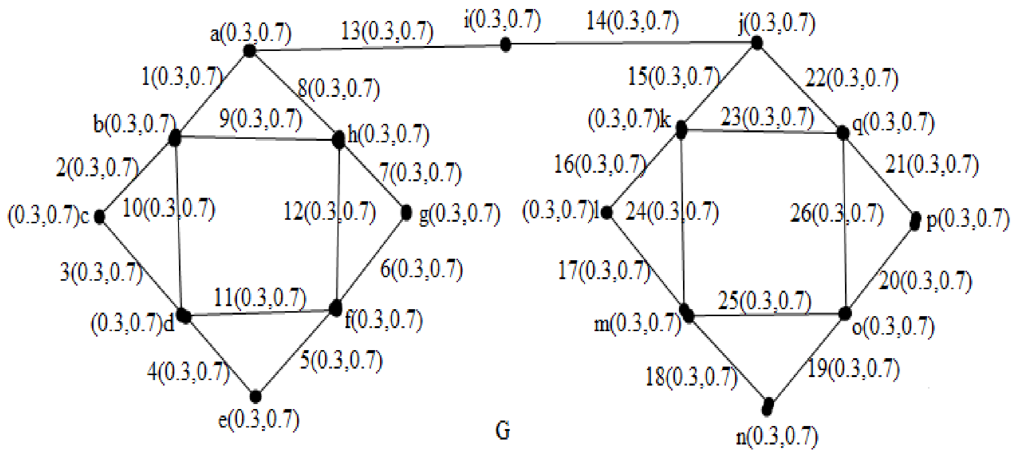

Figure 1:

R_{Te} = {1,3,5,7,15,17,19,21}, E – R_{Te} = {2,4,6,8,9,10,11,12,13,14,16,18,20,22},
p = 4.2, q = 5.2, $\gamma_{eR_T}(G) = 1.8$ $\Delta_{eN}(G) = 1.8$, $\delta_{eN}(G) = 1.6$, |p–q| = |-1| = 1,
$p - \Delta_{eN}(G) = 2.4$, $p - \delta_{eN}(G) = 2.6$, $q - \Delta_{eN}(G) = 3.4$, $q - \delta_{eN}(G) = 3.6$.

4. Equitable regular total semi - μ strong (weak) edge domination in an IFG

In this section, Equitable regular total semi - μ strong (weak) edge dominating number of an intuitionistic fuzzy graph is introduced and its parametric conditions are established. Let us consider p ≤ q throughout the paper.

Definition 4.1. A regular total semi - μ strong (weak) edge dominating set $eERT_{\mu}$ of an intuitionistic fuzzy graph G is an **equitable regular total semi - μ strong (weak) edge dominating set** if

i. u,v∈ E(G) and
ii. | deg(u) – deg(v) | ≤ 1 for all u ∈ ERT_{μ} , v ∈ V-ERT_{μ}

Definition 4.2. An equitable regular total semi - μ strong (weak) edge dominating set $eERT_{\mu}$ of a intuitionistic fuzzy graph G is called **minimal equitable regular total semi -**

μ strong (weak) edge dominating set of G, if $v \in eERT_\mu$, $eERT_\mu$ - {v} is not an equitable regular total semi - μ strong (weak) edge dominating set of G.

Definition 4.3. The minimum fuzzy cardinality among all minimal equitable regular total semi - μ strong (weak) edge dominating set is called **equitable regular total semi - μ strong (weak) edge dominating set** and its equitable regular total semi - μ strong (weak) edge domination number is denoted by $\gamma_{eERT_\mu}(G)$.

Theorem 4.4. For an intuitionistic fuzzy graph,
$\gamma_{eERT_\mu}(G) \le p - \Delta_{e(\mu)}(G) \le q - \delta_{e(\mu)}(G)$

Proof: Let G be an intuitionistic fuzzy graph. Let $\gamma_{eERT_\mu}(G)$ be an equitable regular total semi - μ strong (weak) edge domination number of G.

p - $\Delta_{e(\mu)}$ be a fuzzy vertices but need not be a minimum of an equitable regular total semi - μ strong (weak) edge domination number of G. Then, an equitable regular total semi - μ strong (weak) edge domination number of G is less than or equal to p - $\Delta_{e(\mu)}$. That is, $\gamma_{eERT_\mu}(G) \le p - \Delta_{e(\mu)}(G)$. q- $\delta_{e(\mu)}$ be a fuzzy vertices but need not be a minimum of p- $\Delta_{e(\mu)}$ fuzzy vertices. p- $\Delta_{e(\mu)}$ fuzzy vertices is less than or equal to q- $\delta_{e(\mu)}$.

Therefore, $p - \Delta_{e(\mu)}(G) \le q - \delta_{e(\mu)}(G)$.

Hence, $\gamma_{eRT_\mu}(G) \le p - \Delta_{e(\mu)}(G) \le p - \delta_{e(\mu)}(G)$.

Theorem 4.5. For an intuitionistic fuzzy graph,
$\gamma_{eERT_\mu}(G) \le p - \Delta_{e(\gamma)}(G) \le q - \delta_{e(\gamma)}(G)$

Proof: Let G be an intuitionistic fuzzy graph. Let $\gamma_{eRT_\mu}(G)$ be a regular total strong (weak) edge domination number of G.

q - $\Delta_{e(\gamma)}$ be a fuzzy edges but need not be a minimum of regular total strong (weak) edge domination number of G. Then, a regular total strong (weak) edge domination number of G is less than or equal to q - $\Delta_{e(\gamma)}$. That is, $\gamma_{eRT_\mu}(G) \le q - \Delta_{e(\gamma)}(G)$. q - $\delta_{e(\gamma)}$ be a fuzzy vertices but need not be a minimum of q - $\Delta_{e(\gamma)}$ fuzzy vertices. q - $\Delta_{e(\gamma)}$ fuzzy vertices is less than or equal to q - $\delta_{e(\gamma)}$

Therefore, $q - \Delta_{e(\gamma)}(G) \le q - \delta_{e(\gamma)}(G)$.

Hence, $\gamma_{eERT_\mu}(G) \le p - \Delta_{e(\gamma)}(G) \le q - \delta_{e(\gamma)}(G)$.

Theorem 4.6. For an intuitionistic fuzzy graph, $\gamma_{eERT_\mu}(G) \ge \dfrac{p - \Delta_{e(\gamma)}(G)}{\Delta_{e(\mu)}(G) + 1}$

Proof: Let G be an intuitionistic fuzzy graph. Let γ_{eERT_μ} be an equitable regular total strong (weak) edge domination number of G. $\frac{p - \Delta_{e(\gamma)}(G)}{\Delta_{e(\mu)}(G) + 1}$ be a fuzzy vertices but need not be a maximum of an equitable regular total strong (weak) edge domination number of G. Hence, $\gamma_{eERT_\mu}(G) \geq \frac{p - \Delta_{e(\gamma)}(G)}{\Delta_{e(\mu)}(G) + 1}$.

Theorem 4.7. Let G be an IFG. In an IFG,

$$\frac{O_{e(\mu)}(G) - \Delta_{e(\mu)}(G)}{2} \leq \gamma_{eERT_\mu}(G) \leq \frac{O_{e(\gamma)}(G) - \Delta_{e(\gamma)}(G)}{2}$$

Proof: Let G be an IFG. $\gamma_{eERT_\mu}(G)$ be an equitable regular total semi - µ strong (weak) edge domination of an IFG. $\gamma_{eERT_\mu}(G)$ be an equitable regular total semi - µ strong (weak) edge domination of an IFG but need not be a minimum of a $\frac{O_{e(\mu)}(G) - \Delta_{e(\mu)}(G)}{2}$ fuzzy cardinality of IFG. $\frac{O_{e(\mu)}(G) - \Delta_{e(\mu)}(G)}{2}$ fuzzy cardinality is less than or equal to an equitable regular total semi - µ strong (weak) edge domination of an IFG. That is, $\frac{O_{e(\mu)}(G) - \Delta_{e(\mu)}(G)}{2} \leq \gamma_{eERT_\mu}(G)$. $\frac{O_{e(\gamma)}(G) - \Delta_{e(\gamma)}(G)}{2}$ be a fuzzy vertices but need not be a minimum of an equitable regular total semi - µ strong (weak) edge domination of an IFG. Then, an equitable regular total semi - µ strong (weak) edge domination of an IFG is less than or equal to a $\frac{O_{e(\gamma)}(G) - \Delta_{e(\gamma)}(G)}{2}$ fuzzy vertices. That is, $\gamma_{eERT_\mu}(G) \leq \frac{O_{e(\gamma)}(G) - \Delta_{e(\gamma)}(G)}{2}$.

Hence, $\frac{O_{e(\mu)}(G) - \Delta_{e(\mu)}(G)}{2} \leq \gamma_{eERT_\mu}(G) \leq \frac{O_{e(\gamma)}(G) - \Delta_{e(\gamma)}(G)}{2}$.

Example 4.8. Let G be an IFG. All the edges have (0.3,0.5) membership values.
ERT_μ={1,2,3,4,5,6,32,34,36,38,40,42},
V - ERT_μ =
{7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,33,35,37,39,41}, $\gamma_{eERT_\mu}(G)$= 4.8, p = 9.6, q = 16.8, O(G) = (2.4,7.2), S(G) = (2.4,7.2), W(G) = (3.6,6), $p - \Delta_{e(\gamma)}(G) = 8.1$, $q - \delta_{e(\gamma)}(G) = 15.3$
$p - \Delta_{e(\mu)}(G) = 8.7$, $p - \delta_{e(\mu)}(G) = 8.7$, $\Delta = \delta = (0.9,1.5)$

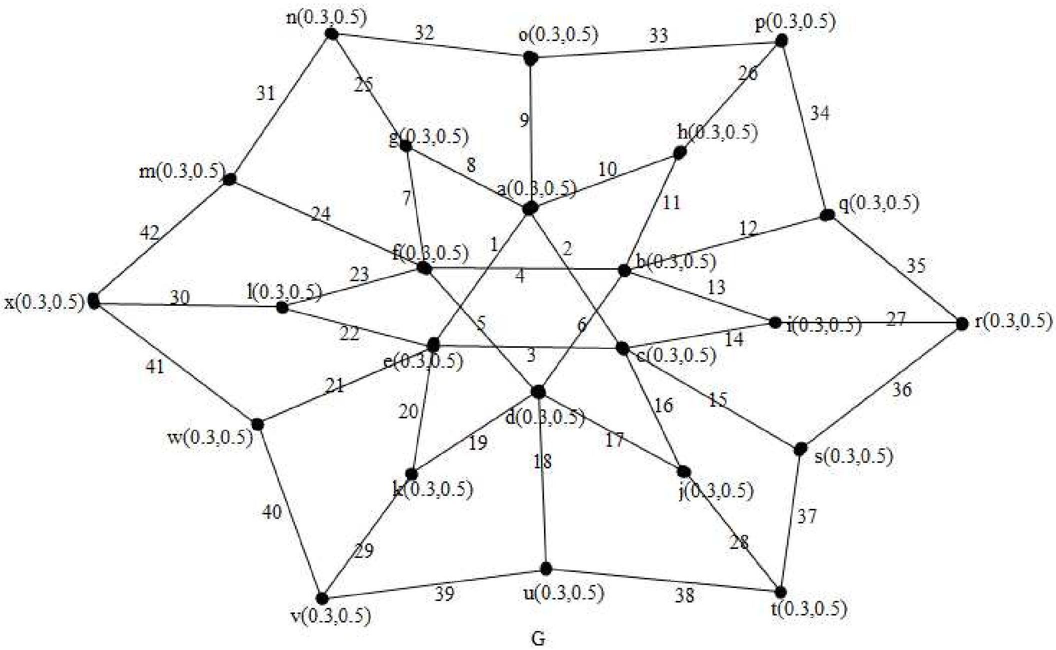

Figure 2:

5. Conclusion

In this paper, an equitable regular total semi - μ strong (weak) edge domination number is defined and established the parametric conditions. The properties of Regular total semi - μ strong (weak) edge domination number and an equitable regular total semi - μ strong (weak) edge domination number domination number are discussed.

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