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Connected Edge Litact Domination in Graphs

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***Abstract:** A subset D of edges dominating in $m(G)$ is connected edge dominating, if $\langle D\rangle$, the subgraph induced by D is connected.The connected edge litact domination number ,$\gamma'_{cm}(G)$ is $\gamma'_{cm}(G) = \min|D|$.In This article we could able to bring up some interesting results on connected edge litact domination number of graph G with its parameters and some domination parameters.*

***Subject classification number**: AMS-05C69, 05C70.*
***Keywords:** Connected edge litact domination number, Litact graph, Litact domination number.*

I. INTRODUCTION

All the notations and their corresponding definitions can be found in F.Harary[3] and V.R.Kulli[8]. Simple, finite, non-trivial, undirected and connected graphs are used to depict the notations.

II. DEFINITIONS

A. Dominating set:

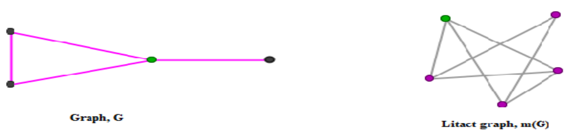
A minimum set of vertices D in G which is in such a way that every vertex of G is either an element of D or neighbour to any vertex of D, then set D is dominating and the domination number $\gamma(G)$ is given by $\gamma(G) = \min|D|$.

B. Connected Dominating set:

A set D of vertices dominating in G whose sub graph $\langle D\rangle$ induced by D is connected then D is a connected dominating set. The connected domination number of G, $\gamma_c(G)$ is given by $\gamma_c(G) = \min|D|$.

C. Litact Graph:

A litact graph $m(G)$, in which the vertices are the edges and cut vertices of G and edges is obtained by connecting the edges and cut vertices when they are adjacent or incident in the graph.
Eg:



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D. Litact Dominating set:

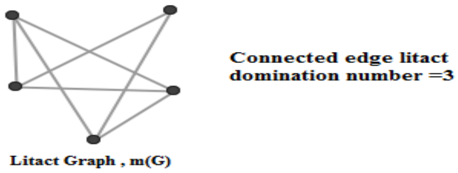
A set D of vertices dominating in $m(G)$ is litact dominating, if there exists an edge between every vertex of $V - D$ with atleast one vertex, v in D. Litact domination number of G, $\gamma_m(G)$ is given by $\gamma_m(G) = \min|D|$.

Eg:

E. Connected Edge Litact Dominating set:

Any set $D \subseteq E(m(G))$ dominating in $m(G)$ is connected edge dominating, if the graph $\langle D\rangle$ is connected in $m(G)$. Connected edge litact domination number, $\gamma'_{cm}(G)$ is given by $\gamma'_{cm}(G) = \min|D|$.

Eg:



III. RESULTS

For more results we require the succeeding theorems.
Theorem A [8]: For any graph G, $\gamma(G) \leq p - \Delta(G)$.
Theorem B [8]: For any graph G , $p - q \leq \gamma(G)$.
Theorem C [8]: For any graph G without isolated vertices, $\frac{q}{\Delta'(G)+1} \leq \gamma'(G)$
Theorem D [8] : For any connected graph G with at least two vertices, $\gamma_t(G) \leq \gamma_c(G)$
Theorem E [8]: For any graph G, $\mathrm{diam}(G) - 1 \leq \gamma_c(G)$
Theorem F [8]: For any graph G, $\gamma(G) \leq \beta_0(G)$.
Theorem G [8]:
For any graph G of order at least three with maximum edge degree $\Delta'(G)$, $\frac{q}{\Delta'(G)+1} \leq \gamma'_c(G)$.
Theorem H [8]**:** In a graph G,
$\frac{p}{\Delta(G)+1} \leq \gamma_c(G) \leq 2q - p$
Theorem I [8]: If a graph G has no isolated vertices, $\gamma[G] \leq \frac{(p+2-\delta(G))}{2}$
Observation: In a cycle graph C_p, with $p \geq 3$ vertices,

$\gamma'_{cm}(G) = p - 2$

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IV. Theorems

In the next theorem, we relate $\gamma'_{cm}(G)$ and p

Theorem 1 : In a graph G with $p \geq 3$ vertices , $\gamma'_{cm}(G) > \frac{p}{5}$

Proof: Let $E = \{e_1, e_2, \ldots \ldots .., e_n\}$ be the edge set and $C = \{c_1, c_2, \ldots \ldots .., c_n\}$ be the cut vertex set in G whose union forms the vertex set of litact graph of G. Let $D = \{q_1, q_2, .., q_n\}$ be the edge set minimal dominating in $m(G)$ so that the sub graph $\langle D \rangle$ induced by D has no vertex v with $d(v) = 0$. Then $|D| = \gamma'_{cm}(G)$. Then we have, $5|D| > |E(m(G))| \geq p$. Therefore $\gamma'_{cm}(G) > \frac{p}{5}$.

In the succeeding theorem we relate $\gamma'_{cm}(G)$ with $\gamma(G)$& q.

Theorem 2: In a graph G, $\gamma'_{cm}(G) > \left\lfloor \frac{\gamma(G)+q}{5} \right\rfloor$

Proof: From Theorem B we have

$p - q \leq \gamma(G) \Rightarrow p \leq q + \gamma(G)$ -----(1)

From Theorem 1 we have

$\gamma'_{cm}(G) > \frac{p}{5} \Rightarrow p < 5\gamma'_{cm}(G)$ ---------(2)

Subtracting (1) from (2) we get

$\gamma(G) + q < 5\gamma'_{cm}(G)$

$\Rightarrow \gamma'_{cm}(G) > \frac{\gamma(G)+q}{5} \geq \left\lfloor \frac{\gamma(G)+q}{5} \right\rfloor$

and hence , $\gamma'_{cm}(G) > \left\lfloor \frac{\gamma(G)+q}{5} \right\rfloor$.

We get a relation for connected edge litact domination number of G with $\gamma(G)$ & $\Delta(G)$

Theorem 3 : In a graph G, $\gamma'_{cm}(G) \geq \frac{1}{5}(\gamma(G) + \Delta(G))$

Proof: We have from Theorem A,

$\gamma(G) \leq p - \Delta(G)$

$\Rightarrow (\gamma(G) + \Delta(G)) \leq p$ ---------(1)

Also by Theorem1 we have

$\gamma'_{cm}(G) > \frac{p}{5} \Rightarrow p < 5\gamma'_{cm}(G)$ ....(2)

From (1) and (2) we get

$(\gamma(G) + \Delta(G)) < 5\gamma'_{cm}(G)$

$\Rightarrow \gamma'_{cm}(G) \geq \frac{1}{5}(\gamma(G) + \Delta(G))$.

We find a relation for $\gamma'_{cm}(G)$ in terms of $\gamma'(G)$

Theorem 4: In a graph G, $\gamma'(G) \leq \gamma'_{cm}(G)$

Proof: Let D be minimal edge set dominating in $m(G)$. And $D_1 \subseteq E(m(G)) - D$ whose union forms a set of edges which is connected edge dominating in $m(G)$. This shows that $|D \cup D_1| = \gamma'_{cm}(G)$. Also let H be the minimal edge dominating set in G which implies $|H| = \gamma'(G)$. We have clearly $|D \cup D_1| \geq |H|$ which gives $\gamma'_{cm}(G) \geq \gamma'(G)$ that is $\gamma'(G) \leq \gamma'_{cm}(G)$.

The following corollary is a relation of $\gamma'_{cm}(G)$ in terms of q and $\Delta'(G)$.

Corollary 1: In a graph G, $\frac{q}{\Delta'(G)+1} \leq \gamma'_{cm}(G)$

Proof: From the theorems, Theorem 4 and Theorem C we get the result.

The theorem below relates $\gamma'_{c}(G)$ & $\gamma'_{cm}(G)$.

Theorem 5: In a graph G , $\gamma'_c(G) \leq \gamma'_{cm}(G)$

Proof: From Corollary 1 we have

$\frac{q}{\Delta'(G)+1} \leq \gamma'_{cm}(G)$ .... (1)

From Theorem G we have

$\frac{q}{\Delta'(G)+1} \leq \gamma'_c(G)$ ……….(2)

Subtracting (2) from (1) , we get the required result.

The following theorem relates $\gamma_t(G)$, $\gamma'_{cm}(G)$ and diameter of G.

Theorem 6: For any graph ,

$\gamma'_{cm}(G) \leq 2diam(G) + \gamma_t(G) + 3$

Proof : Let $E = \{e_1, e_2, \ldots \ldots .., e_n\}$ be the edge set in G such that it constitute the diametral path in G. Then $|E| = diam(G)$. Let M be a subset with vertices of G so that the sub graph $\langle M \rangle$ induced by M which has no vertex v with $d(v) = 0$. This shows that $|M| = \gamma_t(G)$. Let $|D| = \gamma'(G)$. Let $T \subseteq E(m(G)) - D$ is such that the graph $\langle D \cup T \rangle$ is connected in $m(G)$. Then the set $D \cup T$ forms a connected edge dominating set in $m(G)$. This implies $|D \cup T| = \gamma'_{cm}(G)$. Then we have $|D \cup T| \leq 2diam(G) + \gamma_t(G) + 3$ which gives $\gamma'_{cm}(G) \leq 2diam(G) + \gamma_t(G) + 3$.

The next corollary is a relation of $\gamma'_{cm}(G)$ with $\gamma_t(G)$ and diameter of G.

Corollary 2: In a graph G,

$\gamma'_{cm}(G) \leq 2diam(G) + \gamma_c(G) + 3$

Proof : The result follows clearly from Theorem D and Theorem 6.

In the theorem below we get a relation of $\gamma_c(G)$ & $\gamma'_{cm}(G)$

Theorem 7: In a graph G, $\gamma_c(G) \leq \gamma'_{cm}(G)$

Proof : Let $S \subseteq V(G)$ whose sub graph $\langle S \rangle$ is connected in G . This gives $|S| = \gamma_c(G)$. Let D be an edge set dominating set in $m(G)$ and $M \subseteq E(m(G)) - D$ .Then clearly $D \cup M$ will form an dominating edge set which is connected in $m(G)$ and which implies $|D \cup M| = \gamma'_{cm}(G)$. Since the set $D \cup M$ contains at least $\gamma_c(G)$ edges, we have $|D \cup M| \geq |S|$ which gives $\gamma'_{cm}(G) \geq \gamma_c(G)$ that is $\gamma_c(G) \leq \gamma'_{cm}(G)$.

The next corollary gives a relation of diameter & $\gamma'_{cm}(G)$

Corollary 3: In a graph G, $diam(G) - 1 \leq \gamma'_{cm}(G)$

Proof : The result follows from Theorem E and Theorem 7.

In the next corollary we relate the $\gamma(G)$ and $\gamma'_{cm}(G)$.

Corollary 4: For each graph , $\gamma(G) \leq \gamma'_{cm}(G)$

Proof : Since $\gamma(G) \leq \gamma_c(G)$ and from Theorem7, the proof is clear.

The next corollary relates $\gamma'_{cm}(G)$ and $\gamma_c(G)$ & $\gamma(G)$

Corollary 5: In a graph G, $\gamma'_{cm}(G) \geq 2(\gamma_c(G) + \gamma(G))$

Proof : The proof follows from Corollary 4 and Theorem 7

The following corollary gives a relation of $\gamma'_{cm}(G)$ with p & $\delta(G)$

Corollary 6: For each graph G, $\gamma'_{cm}(G) \geq \left\lfloor \frac{p+2-\delta(G)}{2} \right\rfloor$, except for p_3

Proof: Corollary 4 gives

$\gamma(G) \leq \gamma'_{cm}(G)$………..(1)

Theorem I gives ,

$\gamma[G] \leq \frac{(p+2-\delta(G))}{2}$………..(2)

Subtracting (2) from (1) we get ,

$\frac{(p+2-\delta(G))}{2} \leq \gamma'_{cm}(G)$………..(3)

But we know $\left\lfloor \frac{(p+2-\delta(G))}{2} \right\rfloor < \frac{(p+2-\delta(G))}{2}$……..(4)

From (3) and (4) we get the result.

The following corollary gives a relation for $\gamma'_{cm}(G)$ with $\Delta(G)$.

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Corollary 6: For each graph , $\left\lceil \frac{p}{\Delta(G)+1} \right\rceil \leq \gamma'_{cm}(G)$

Proof : From Corollary 4 we get,

$\gamma(G) \leq \gamma'_{cm}(G)$ ……….(1)

From Theorem H we have,

$\frac{p}{\Delta(G)+1} \leq \gamma_c(G)$ ………..(2)

Since $\gamma(G) \leq \gamma_c(G)$ and from (1) & (2), the proof is clear.

The next corollary gives a relation of $\gamma'_{cm}(G)$ with p & q

Corollary 7: In a graph G, $p - q \leq \gamma'_{cm}(G)$

Proof : We get the result from Theorem B and Corollary 4.

In the next theorem we extract a relation for $\gamma'_{cm}(G)$ with $\beta_0(G)$.

Theorem 8 : In a graph G, $\gamma'_{cm}(G) \leq \beta_0(G) + 5$

Proof : From Corollary 4, we have

$\gamma(G) \leq \gamma'_{cm}(G)$ ………… (1)

From Theorem F we have

$\gamma(G) \leq \beta_0(G) < \beta_0(G) + 5$

$\Rightarrow \gamma(G) < \beta_0(G) + 5$ ………..(2)

Subtracting (1) from (2) we get the result.

The following theorem is a relationship between $\gamma'_{cm}(G)$ and p & $\alpha_0(G)$.

Corollary 8 : In a graph G, $\gamma'_{cm}(G) \leq p - \alpha_0(G) + 5$

Proof : From Theorem 8 we have

$\gamma'_{cm}(G) \leq \beta_0(G) + 5$ -------------(1)

And we know that $\alpha_0(G) + \beta_0(G) = p$ --------------(2)

From equations (1) and (2) we get the result.

The following theorem is a relationship between $\gamma'_{cm}(G)$ and q.

Theorem 9: **For each graph G,** $\gamma'_{cm} \leq q + 1$

Proof: Let $D \subseteq E(m(G))$ be an edge set dominating in $m(G)$ and Let R be any subset of $E(m(G)) - D$ in which there exists an edge between every pair of vertices u, v in R. Then the induced sub graph formed by R will be a connected set edge dominating in $m(G)$. This implies $|D \cup R| = \gamma'_{cm}(G)$. Since $D \cup R$ contains at most $q + 1$ edges, we have

$|D \cup R| \leq q + 1$ which gives $\gamma'_{cm}(G) \leq q + 1$.

In the next theorem we relate $\gamma'_{cm}(G)$ with p, q & $\delta(G)$

Theorem 10: In a graph G, $\left\lceil \frac{p}{1+\delta(G)} \right\rceil \leq q + \gamma'_{cm}(G)$.

Proof : Let p, q and $\delta(G)$, represent respectively number of vertices, edges and the minimal connectivity of a vertex. Let D represent the minimal edge dominating set whose induced subgraph is connected in G. This gives $|D| = \gamma'_{cm}(G)$.Then we have

$$\left\lceil \frac{p}{1+\delta(G)} \right\rceil < \big||E(G)| + |D|\big|$$
$$\leq |E(G)| + |D|$$
$$= q + \gamma'_{cm}(G) .$$

And hence we get the required result.

The following theorem relates $\gamma'_{cm}(G)$ and $\alpha_0(G)$

Theorem 11: In a graph G, we have

$$\left\lfloor \frac{\gamma'_{cm}(G)}{2} \right\rfloor \leq \alpha_0(G).$$

Proof : Let $V \subseteq V(m(G))$ be minimal vertex set Which covers every edge in Gand hence $|V| = \alpha_0(G)$.

And let D be an edge set in $m(G)$ whose induced sub graph is so that there is an edge between any two vertices. Then D will be an edge set dominating connected in $m(G)$which gives clearly $\left\lfloor \frac{|D|}{2} \right\rfloor \leq |V|$ and hence

$\left\lfloor \frac{\gamma'_{cm}(G)}{2} \right\rfloor \leq \alpha_0(G)$.

The next corollary gives a relation for $\gamma'_{cm}(G)$ with $\gamma(G), p$ & $\alpha_0(G)$

Theorem 12: In a graph G, we have
$\gamma'_{cm}(G) + \gamma(G) \leq p + \alpha_0(G)$.

Proof: The Theorem 11 gives

$$\left\lfloor \frac{\gamma'_{cm}(G)}{2} \right\rfloor \leq \alpha_0(G)$$

But we have $\frac{\gamma'_{cm}(G)}{2} \leq \left\lfloor \frac{\gamma'_{cm}(G)}{2} \right\rfloor \leq \alpha_0(G)$

This gives $\frac{\gamma'_{cm}(G)}{2} \leq \alpha_0(G)$

$\Rightarrow \gamma'_{cm}(G) \leq 2\,\alpha_0(G)$ ……..(1)

Theorem F gives $\gamma(G) \leq \beta_0(G)$ ……….. (2)

Adding (1) & (2) we get

$$\gamma(G) + \gamma'_{cm}(G) \leq \beta_0(G) + 2\,\alpha_0(G) = p + \alpha_0(G)$$

Which implies $\gamma'_{cm}(G) + \gamma(G) \leq p + \alpha_0(G)$

In the next theorem we obtain a relation of $\gamma'_{cm}(G)$ in terms of $\gamma(G), \gamma'(G), \gamma_c(G)$.

Theorem 13 : In a graph G,
$\frac{1}{3}\big(\gamma(G) + \gamma'(G) + \gamma_c(G)\big) \leq \gamma'_{cm}(G)$.

Proof : From Theorem 5 we have,

$\gamma'(G) \leq \gamma'_{cm}(G)$………..(1)

From Theorem 7 we have,

$\gamma_c(G) \leq \gamma'_{cm}(G)$ ………..(2)

and from Corollary 4 we have,

$\gamma(G) \leq \gamma'_{cm}(G)$………..(3).

Adding three equations we get the result.

We obtain a relation of $\gamma'_{cm}(G)$ with p and $\gamma(G)$.

Theorem 14 : In a graph G, $\gamma'_{cm}(G) + p \leq 1 + \gamma(G)$.

Proof: We have From Theorem B ,

$p - q \leq \gamma(G)$.

This implies $p - \gamma(G) \leq q$………(1)

From Theorem 9 we have

$\gamma'_{cm} \leq q + 1$

this implies $\gamma'_{cm} - 1 \leq q$ ………(2)

Adding (1) and (2) we get

$\gamma'_{cm} - 1 + p + \gamma(G) \leq 0$ and this gives the result.

***Theorem* 15 : For any tree,** $\alpha_0(T) - 1 \leq \left\lceil \frac{\gamma'_{cm}(G)}{2} \right\rceil$ **where** $\alpha_0(T)$ **is the vertex covering number of T.**

Proof : Consider a tree T with $V(T) = \{v_1, v_2, \dots \dots v_n\}$. Let $V_1(T) \subseteq V(T)$ be a set of vertices where every edge has atleast one end point in the vertex cover that is, $|V_1| = \alpha_0(T)$. Let D be the set of minimum edges in the litact graph $m(G)$ in which the subgraph traced by them will be a connected graph. So D will be a connected edge litact dominating set of G which gives $|V_1| - 1 \leq \frac{|D|}{2}$

$\Rightarrow \alpha_0(T) - 1 \leq \frac{\gamma'_{cm}(G)}{2} \leq \left\lceil \frac{\gamma'_{cm}(G)}{2} \right\rceil$

$\Rightarrow \alpha_0(T) - 1 \leq \left\lceil \frac{\gamma'_{cm}(G)}{2} \right\rceil$.

V. Conclusion Remarks

Graph properties has a significant role in encryption .A dominating set of a graph is used to break the code easily.

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In the information retrieval system, the dominating set and the elements of connected edge litact dominating sets can stand alone to make the process of communication more easy. Also it has wide applications in
coding theory, computer science, switching circuits, electrical networks etc.,
In this paper we extend litact dominating set to connected edge litact dominating set of a graph.
The accurate values of this new variant is calculated for different graphs and obtained the upper and lower bounds of it with different parameters of a graph. One can extend this work by studying their applications in a wider sense.

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