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Comparison of Type 2 Fuzzy Numbers with Normal and Crashing Activity in Construction Project

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Abstract : Type 2 fuzzy sets embellish the power to act of the system for dealing with uncertainties. When activities are crashed, it is accessible that more resources are to be spent. In many aspect, we may be curious in finding the lowest setup project finishing time. So crashing network applied in Construction project by utilizing Type 2 Triskaidecagonal Fuzzy number.

Keywords and phrases : Time cost trade off, Normal, Crashing network

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1 Introduction, Notations and Definitions :

Type 1 fuzzy set does not apprehend uncertainty in its exhibition when it arises from vagueness by reason of their membership functions is totally crisp. Type 2 fuzzy sets are useful in these circumstances. Type 2 fuzzy set itself is fuzzy which characterizes type 2 fuzzy logic. In any project network, the initial stage is to find out the critical path with normal activity timings. Then the accomplishment of various stage of being active can be crash. Normal time is the time taken to execute an activity under normal circumstances. Crash time is the minimum duration of an action beyond which it is not possible to make less it anymore based on the algorthim [4]. This paper includes with definition, algorthim and illustration calculated with crashing method.

Definition :

Type-2 Trapezoidal Fuzzy Number : Let $a = (a_1 , a_2, a_3, a_4)$ be a trapezoidal fuzzy number. A normal type-2 trapezoidal fuzzy number $\tilde{A} = \{ (x, \mu_A^L(x), \mu_A^M(x), \mu_A^N(x), \mu_A^U(x))\}$, $x \varepsilon R$ and $\mu_A^L(x) \le \mu_A^M(x) \le \mu_A^N(x) \le \mu_A^U(x)$, for all $x \varepsilon R$.Denote $\tilde{A} = (A^L , A^M, A^N, A^U)$, where $\tilde{A} = ((a_1^L, a_2^L, a_3^L, a_4^L),(a_1^M, a_2^M, a_3^M, a_4^M),(a_1^N, a_2^N, a_3^N, a_4^N)\ (a_1^U, a_2^U, a_3^U, a_4^U))$.

Type-2 Triskaidecagonal Fuzzy number :

A type-2 Triskaidecagonal fuzzy number

$$\tilde{A} = \{(x, \mu_A^1(X), \mu_A^2(X), \mu_A^3(X), \mu_A^4(X), \mu_A^5(X), \mu_A^6(X), \mu_A^7(X), \mu_A^8(X), \mu_A^9(X), \mu_A^{10}(X), \mu_A^{11}(X), \mu_A^{12}(X), \mu_A^{13}(X)); X \varepsilon R\}$$

$$(\mu_A^1(X) \leq \mu_A^2(X) \leq \mu_A^3(X) \leq \mu_A^4(X) \leq \mu_A^5(X) \leq \mu_A^6(X) \leq \mu_A^7(X) \leq \mu_A^8(X) \leq \mu_A^9(X) \leq \mu_A^{10}(X) \leq \mu_A^{11}(X) \leq \mu_A^{12}(X) \mu_A^{13}(X))$$

for all $X \varepsilon R$

Denote, $\tilde{A} = (\widetilde{A_1}, \widetilde{A_2}, \widetilde{A_3}, \widetilde{A_4}, \widetilde{A_5}, \widetilde{A_6}, \widetilde{A_7}, \widetilde{A_8}, \widetilde{A_9}, \widetilde{A_{10}}, \widetilde{A_{11}}, \widetilde{A_{12}}, \widetilde{A_{13}})$

Where $\widetilde{A_1} = (\widetilde{A_1^\alpha}, \widetilde{A_1^\beta}, \widetilde{A_1^\sigma}, \widetilde{A_1^\delta}, \widetilde{A_1^\iota}, \widetilde{A_1^\eta}, \widetilde{A_1^\rho}, \widetilde{A_1^\upsilon}, \widetilde{A_1^\varphi}, \widetilde{A_1^\omega}, \widetilde{A_1^\chi}, \widetilde{A_1^\tau}, \widetilde{A_1^\theta})$, $\widetilde{A_2} = (\widetilde{A_2^\alpha}, \widetilde{A_2^\beta}, \widetilde{A_2^\sigma}, \widetilde{A_2^\delta}, \widetilde{A_2^\iota}, \widetilde{A_2^\eta}, \widetilde{A_2^\rho}, \widetilde{A_2^\upsilon}, \widetilde{A_2^\varphi}, \widetilde{A_2^\omega}, \widetilde{A_2^\chi}, \widetilde{A_2^\tau}, \widetilde{A_2^\theta})$, $\widetilde{A_3} = (\widetilde{A_3^\alpha}, \widetilde{A_3^\beta}, \widetilde{A_3^\sigma}, \widetilde{A_3^\delta}, \widetilde{A_3^\iota}, \widetilde{A_3^\eta}, \widetilde{A_3^\rho}, \widetilde{A_3^\upsilon}, \widetilde{A_3^\varphi}, \widetilde{A_3^\omega}, \widetilde{A_3^\chi}, \widetilde{A_3^\tau}, \widetilde{A_3^\theta})$, $\widetilde{A_4} = (\widetilde{A_4^\alpha}, \widetilde{A_4^\beta}, \widetilde{A_4^\sigma}, \widetilde{A_4^\delta}, \widetilde{A_4^\iota}, \widetilde{A_4^\eta}, \widetilde{A_4^\rho}, \widetilde{A_4^\upsilon}, \widetilde{A_4^\varphi}, \widetilde{A_4^\omega}, \widetilde{A_4^\chi}, \widetilde{A_4^\tau}, \widetilde{A_4^\theta})$, $\widetilde{A_5} = (\widetilde{A_5^\alpha}, \widetilde{A_5^\beta}, \widetilde{A_5^\sigma}, \widetilde{A_5^\delta}, \widetilde{A_5^\iota}, \widetilde{A_5^\eta}, \widetilde{A_5^\rho}, \widetilde{A_5^\upsilon}, \widetilde{A_5^\varphi}, \widetilde{A_5^\omega}, \widetilde{A_5^\chi}, \widetilde{A_5^\tau}, \widetilde{A_5^\theta})$, $\widetilde{A_6} = (\widetilde{A_6^\alpha}, \widetilde{A_6^\beta}, \widetilde{A_6^\sigma}, \widetilde{A_6^\delta}, \widetilde{A_6^\iota}, \widetilde{A_6^\eta}, \widetilde{A_6^\rho}, \widetilde{A_6^\upsilon}, \widetilde{A_6^\varphi}, \widetilde{A_6^\omega}, \widetilde{A_6^\chi}, \widetilde{A_6^\tau}, \widetilde{A_6^\theta})$, $\widetilde{A_7} = (\widetilde{A_7^\alpha}, \widetilde{A_7^\beta}, \widetilde{A_{17}^\sigma}, \widetilde{A_7^\delta}, \widetilde{A_7^\iota}, \widetilde{A_7^\eta}, \widetilde{A_7^\rho}, \widetilde{A_7^\upsilon}, \widetilde{A_7^\varphi}, \widetilde{A_7^\omega}, \widetilde{A_7^\chi}, \widetilde{A_7^\tau}, \widetilde{A_7^\theta})$, $\widetilde{A_1} = (\widetilde{A_8^\alpha}, \widetilde{A_8^\beta}, \widetilde{A_8^\sigma}, \widetilde{A_8^\delta}, \widetilde{A_8^\iota}, \widetilde{A_8^\eta}, \widetilde{A_8^\rho}, \widetilde{A_8^\upsilon}, \widetilde{A_8^\varphi}, \widetilde{A_8^\omega}, \widetilde{A_8^\chi}, \widetilde{A_8^\tau}, \widetilde{A_8^\theta})$, $\widetilde{A_9} = (\widetilde{A_9^\alpha}, \widetilde{A_9^\beta}, \widetilde{A_9^\sigma}, \widetilde{A_9^\delta}, \widetilde{A_9^\iota}, \widetilde{A_9^\eta}, \widetilde{A_9^\rho}, \widetilde{A_1^\upsilon}, \widetilde{A_1^\varphi}, \widetilde{A_1^\omega}, \widetilde{A_1^\chi}, \widetilde{A_1^\tau}, \widetilde{A_1^\theta})$, $\widetilde{A_{10}} = (\widetilde{A_{10}^\alpha}, \widetilde{A_{10}^\beta}, \widetilde{A_{10}^\sigma}, \widetilde{A_{10}^\delta}, \widetilde{A_{10}^\iota}, \widetilde{A_{10}^\eta}, \widetilde{A_{10}^\rho}, \widetilde{A_{10}^\upsilon}, \widetilde{A_{10}^\varphi}, \widetilde{A_{10}^\omega}, \widetilde{A_{10}^\chi}, \widetilde{A_{10}^\tau}, \widetilde{A_{10}^\theta})$, $\widetilde{A_{11}} = (\widetilde{A_{11}^\alpha}, \widetilde{A_{11}^\beta}, \widetilde{A_{11}^\sigma}, \widetilde{A_{11}^\delta}, \widetilde{A_{11}^\iota}, \widetilde{A_{11}^\eta}, \widetilde{A_{11}^\rho}, \widetilde{A_{11}^\upsilon}, \widetilde{A_{11}^\varphi}, \widetilde{A_{11}^\omega}, \widetilde{A_{11}^\chi}, \widetilde{A_{11}^\tau}, \widetilde{A_{11}^\theta})$, $\widetilde{A_{12}} = (\widetilde{A_{12}^\alpha}, \widetilde{A_{12}^\beta}, \widetilde{A_{12}^\sigma}, \widetilde{A_{12}^\delta}, \widetilde{A_{12}^\iota}, \widetilde{A_{12}^\eta}, \widetilde{A_{12}^\rho}, \widetilde{A_{12}^\upsilon}, \widetilde{A_{12}^\varphi}, \widetilde{A_{12}^\omega}, \widetilde{A_{12}^\chi}, \widetilde{A_{12}^\tau}, \widetilde{A_{12}^\theta})$, $\widetilde{A_{13}} = (\widetilde{A_{13}^\alpha}, \widetilde{A_{13}^\beta}, \widetilde{A_{13}^\sigma}, \widetilde{A_{13}^\delta}, \widetilde{A_{13}^\iota}, \widetilde{A_{13}^\eta}, \widetilde{A_{13}^\rho}, \widetilde{A_{13}^\upsilon}, \widetilde{A_{13}^\varphi}, \widetilde{A_{13}^\omega}, \widetilde{A_{13}^\chi}, \widetilde{A_{13}^\tau}, \widetilde{A_{13}^\theta})$

are same type of fuzzy numbers.

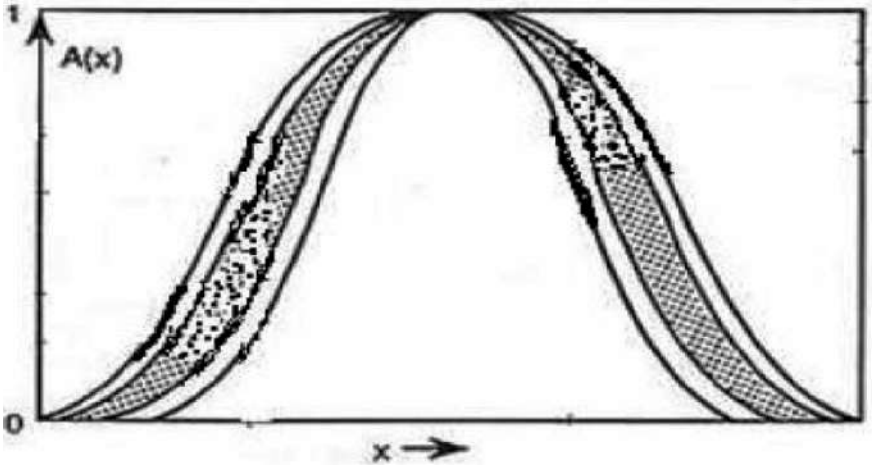


Fig : Illustration of the concept of a type-2 Triskaidecagonal fuzzy set.

Table 1: Details of the Project Duration:

Activity Number	Activity	Normal Time (N_t)	Crash Time (C_t)
A	1 → 2	(50,52,54,57),(49,52,54,58), (47,50,58,60),(31,50,58,74)	(41,30,35,39),(40,30,35,40), (36,29,37,43),(16,29,37,63)
B	2 → 3	(55,58,60,65),(53,58,60,67), (51,56,62,69),(40,56,62,80)	(50,52,54,57),(49,52,54,58), (45,50,58,60),(21,50,68,74)
C	3 → 4	(49,51,53,56),(48,51,53,57), (48,50,53,58),(35,50,53,71)	(41,30,35,39),(40,30,35,40), (36,29,37,43),(16,29,37,63)
D	4 → 5	(50,52,54,57),(49,52,54,58), (47,50,58,60),(31,50,58,74)	(41,30,35,39),(40,30,35,40), (36,29,37,43),(16,29,37,63)
E	4 → 6	(55,58,60,65),(53,58,60,67), (51,56,62,69),(40,56,62,80)	(41,30,35,39),(40,30,35,40), (36,29,37,43),(16,29,37,63)
F	5 → 6	(50,52,54,57),(49,52,54,58), (47,51,56,59),(34,51,56,72)	(41,30,35,39),(40,30,35,40), (36,29,37,43),(16,29,37,63)
G	6 → 7	(45,52,58,61),(43,52,58,63), (42,50,59,65),(27,50,59,80)	(42,35,40,44),(41,35,40,45), (38,34,42,47),(15,34,42,70)

Illustration :

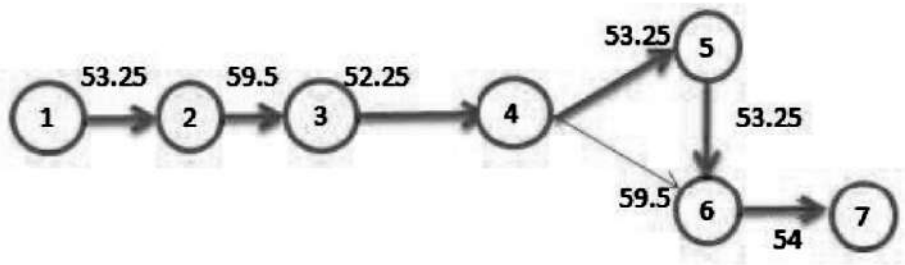
A construction of independent house with first floor around 1000 sq.ft has listed down with various activities involved. Type 2 Triskaidecagonal fuzzy number applied in this defined problem in order to get the total cost and the project duration. The main stages are -

Stage- 1: Planning & design
Stage- 2: Permit application
Stage- 3: Tendering & Foundation
Stage- 4: Construction Process
Stage- 5: Interior and Exterior work
Stage- 6: Detailed finishing & Evaluation
Stage- 7: Clean up and final touches

Table 2 : Details of the Project Cost :

Activity Number	Activity	Normal Cost (N_c)	Crash Cost (C_c)
A	1 → 2	(280000,320000,340000,380000), (260000,320000,340000,400000), (230000,310000,360000,420000), (200000,310000,360000,450000)	(520000,550000,650000,720000), (500000,550000,650000,740000), (460000,540000,680000,760000), (440000,540000,680000,780000)
B	2 → 3	(550000,580000,620000.700000), (500000,580000,620000,750000), (440000,550000,660000,800000), (380000,550000,660000,860000)	(640000,680000,720000,860000), (600000,680000,720000,900000), (560000,670000,740000,930000), (530000,670000,740000,960000)
C	3 → 4	(500000,550000,600000,650000), (450000,550000,600000,700000), (400000,540000,620000,740000), (360000,540000,620000,780000)	(500000,550000,600000,760000), (480000,550000,600000,780000), (450000,540000,620000,800000), (430000,540000,620000,820000)
D	4 → 5	(280000,320000,340000,380000), (260000,320000,340000,400000), (230000,310000,360000,420000), (200000,310000,360000,450000)	(740000,790000,830000,920000), (720000,790000,830000,940000), (690000,780000,850000,960000), (660000,780000,850000,990000)
E	4 → 6	(260000,330000,350000,480000), (240000,330000,350000,500000), (220000,320000,370000,510000), (180000,320000,370000,550000)	(430000,500000,680000,750000), (380000,500000,680000,800000), (300000,490000,700000,870000), (200000,480000,700000,980000)

F	5 → 6	(500000,550000,600000,650000), (450000,550000,600000,700000), (400000,540000,620000,740000), (360000,540000,620000,780000)	(640000,700000,780000,820000), (610000,700000,780000,850000), (560000,680000,800000,900000), (470000,680000,800000,990000)
G	6 → 7	(550000,580000,620000,700000), (500000,580000,620000,750000), (440000,550000,660000,800000), (260000,550000,660000,980000)	(430000,500000,680000,750000), (380000,500000,680000,800000), (350000,490000,700000,820000), (320000,480000,700000,860000)



Critical Path = 1 → 2 → 3 → 4 → 5 → 6 → 7

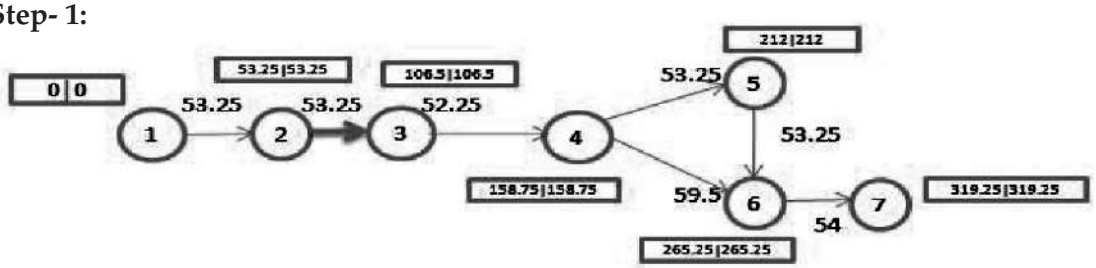
Project Duration = 53.25 + 59.5 + 52.25 + 53.25 + 53.25 + 54 = 325.5 days

Table 3 : Details of the slope cost

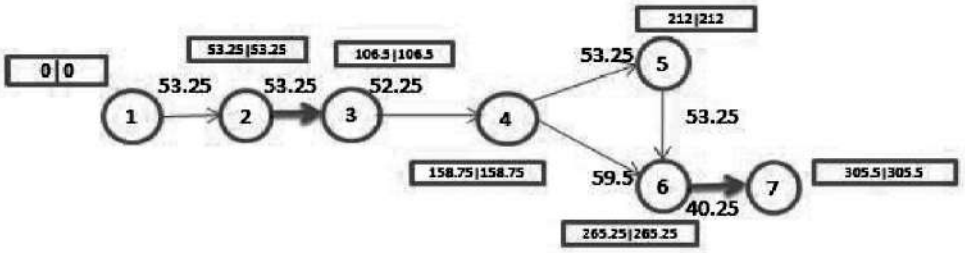
Activity Number	Activity	Nt	Ct	Nc	Cc	Δt= Nt - Ct	Δt= Cc - Nc	Δc/Δt
A	1 → 2	53.25	36.25	330000	610000	17.00	280000	16470.588
B	2 → 3	59.50	53.25	612500	725000	6.25	112500	18000
C	3 → 4	52.25	36.25	575000	602500	16.00	27500	1718.75
D	4 → 5	53.25	36.25	330000	820000	17.00	490000	28823.52
E	4 → 6	59.50	36.25	355000	590000	23.25	235000	10107.52
F	5 → 6	53.25	36.25	575000	735000	17.00	160000	9411.764
G	6 → 7	54.00	40.25	590000	612500	13.75	22500	1636.36

Direct cost = Rs 33, 67500, **Indirect cost=** Rs 0 **Total cost=** Rs 33, 67500

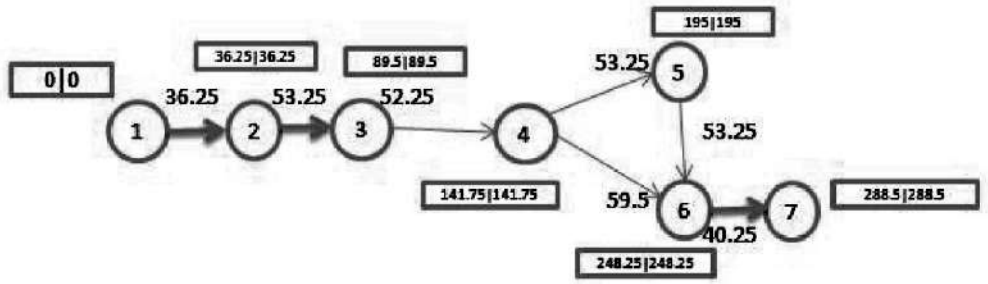
Step- 1:



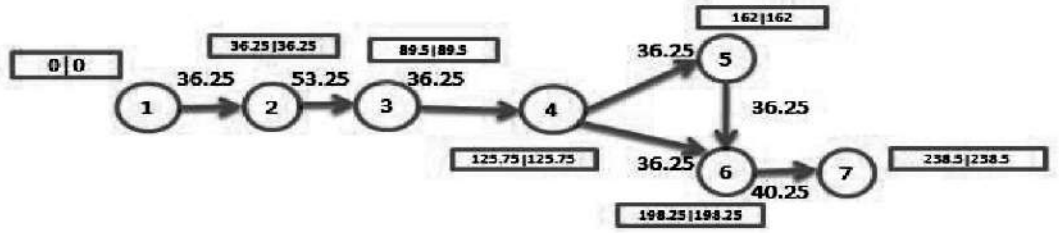
Step- 2 :



Step- 3 :



Step- 4 :



Conclusion:

The normal time and crash time of an activity of Type 2 Triskaidecagonal fuzzy number has been compared with Type 2 Trapezoidal fuzzy number to find total cost and duration of the construction project. The crashing of a network increases the direct cost because of expedition of activities. But it results in decreased project completion time.

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