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Point Fire Detectors Arrangement in Special Cases-The slope Roofs case

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ABSTRACT
Fire Detectors Arrangement Purports A Great Knowledge And Experience In Fire Protection. Although This Task Was Regulated By Several Valid Standards, It Is Not Always Simple To Realize It. Beside \`Normal\` Cases For Fire Detectors Arrangement (For Example, Objects With Standard Geometry Shapes) There Can Be Found Lot Of \`Special\` Cases For Fire Detectors Arrangement. Those \`Special\` Cases Can Be Stairs, Slope Roofs, Girts, Ventilation System And Similar. They Are Also Regulated By Valid Standards, But There Are Some Differences Between Standards. This Paper Has Written To Present Simulation Results For Smoke Detectors In The Case Of Slope Roof With Different Roof\`S Slope, According To VDE 088-2 Standard.

Key Words: Detector, Slope, Roof, Simulation

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I. INTRODUCTION

The Right Timed Fire Detection Is The Most Important Thing In Fire Protection In The Case When Fire Starts. Fire, As An Uncontrolled Burning Can Endanger Human Lives And Cause Huge Material Damage.As An Uncontrolled Occurrence, Fire Cannot Be Completely Predicted, But There Are Lots Of Preventive Tasks That Can Be Realized In Order To, As Much As Possible, Protect And Moderate From Fire Consequences. For Example, As A Fire Endanger Measurement Of Some Object, The Fire Load Is Taken And It Presents Heat Value Of Complete Combustible Material Related To Area Unit. Materials Used For Buildings And Objects Have Different Fire Resistance (Stone, Steel, Concrete, Wood, Brick And Similar). Material Classification According To Results Realized By Fire Reactions Are Defined By Standards (For Example, SRPS EN-13501-1, SRPS U.J1.050 And Others). Many New And Accomplished Materials Showed Great Properties Related To Fire And Other Resistances (Such As, For Example, New Concrete Types).

So, It Is From Crucial Importance To Detect Fire At Early Stage. That Role Was Intended To Fire Detectors. Fire Detectors Can Be Defined On Several Ways. They Can Also Be Divided On Several Ways According To Different Factors. Their Basic Task Is Reliable Fire Detection And Identification Of Fire Start. The Most Important Factor That Determinates Fire Detector\`S Efficiency Is Fire Detector\`S Response Time. There Are Also Several Factors As Very Important Properties Of Fire Detectors: Fire Detector\`S Sensitivity, Fire Detector\`S Inertia, Fire Detector\`S Effect Zone And Disturbance Protection. In Order That Fire Detector Can Achieve Designed Efficiency, It Is Very Important To Define Needed Fire Detectors Number For Every Supervised Area. This Task Is An Object Of Several Valid Standards, Such As: EN 54 (European Norms), BS (British Standard), NFPA 72 (National Fire Protection Association), НПБ 88-2001 (*Нормыпожарнойбезопасности*), VDE 088-2(*Verband Der Elektrotechnik-Originally-Association Of German Electrical Engineers, Now-Association For Electrical, Electronic & Information Technologies*) And Other. The Division Of Supervised Area With Detector Supervised Area Presents The General Rule For Needed Number Of Fire Detectors. Ifdivision Result Doesn't Provide Whole Number, The First Bigger Whole Number Should Be Taken. It Is Also Important To Consider Lot Of Other Different Factors, Such As Shape And Slope Of The Roofs, Walls And Barriers Positioning, Girts Positioning, Room\`S Height, Thickness Of Object\`S Walls And Material That They Made From (Concrete, Gypsum Or Some Other Materials), Humidity, Air Flows And Other

Potential Disturbances. Detectors Location Must Be Easily Accessible, In Case Of Theirs Testing And Repairing. Also, Very Important Fact Is The Distance Of Fire Detectors From Walls And It Must Not Be Less Than 0.5 M Except In Some Special Cases, Such As Narrow Hallways, Passages And Similar. The Rangereduction Between Fire Detectors Can Provide Higher Sensibility, But It Certainly Can't Be Accept As A Rule That Bigger Fire Detector`S Number Causesthat Whole System Has Bigger Sensitivity. The Best Way In Sense Of Safety And Economy Is To Find An Optimal Relation Between Needed Fire Detectors Number And Fire Protection System Sensitivity.

Of Course, There Are Special Cases For Fire Detectors Arrangement, The Cases With Stairs, No Typical Geometry Objects, Girts, Galleries, Slope Roofs, Duplicate Roofs And Narrow Hallways Must Be Considered. Those Cases Also Must Be Arranged In Accordance With Valid Rules Defined By Standards. Objects With Slope Roofs Present Very Interesting Cases Because Different Standards Have Different Interpretation For This Case. As An Example, German Standard VDE 0832-2 Was Taken [1-6].

German Standard VDE 0832-2 Defines Similar Rules For Fire Detectors Arrangement Above Slope Roofs With Thing That Especially Defines Rules For Roof`S Slope Of 20° And Slope Bigger Than 20°. In Basic Rules For Point Fire Detectors Arrangement, It Was Noted That For Slope Bigger Than 20° And Supervised Area Surface Bigger Than 80 M^2, Covering Surface Of Single Smoke Detector Can Be 90 M^2 And 110 M^2 For Heights From 6 M To 12 M. For Example, For Heat Detectors, That Surface Is 40 M^2, For Heights Up To 6 M And 7.5 M, For Rooms With Surface Bigger Than 30 M^2.

Point Smoke And Heat Detectors Can Be Positioned Directly At Slope Roof But With Order For The Slope Angle. Heat Detectors In That Case Are Positioned Directly To Roof While Smoke Detectors Are Positioned At Range D_L From Roof, In Dependence From Room`S Height, Top Of The Roof And Expected Smoke Development Or Heat Limited Layer In Order With Roof`S Shape, As It Is Presented In Table 1.

Table 1.*Distance Of Point Smoke Detectors At Slope Roof* (Table Source: *Fire Protection Systems Designing, Milan Blagojević, Unpublished*)

Room`S Height R_H	Slope Of The Roof A	
	A< 20°	A> 20°
	D_L	D_L
Up To 6 M	Mostly Up To 0.25 M	From 0.2 M To 0.5 M
From 6 M To 12 M	Mostly Up To 0.4 M	From 0.35 M To 1 M
(From 12 M To 16 M)*	From 6 M To 12 M	From 0.5 M To 1.2 M

*- In Dependence From Ambient Characteristics, I.E. The Way Of Smoke Development And Spreading

In Addition, German Standard Especially Considers Fire Detectors Arrangement Above Roofs With Slope Bigger Than 20°, As It Is Presented On Figure 1 And For Roofs With Several Slopes, As It Is Presented On Figure 2 [7-12].

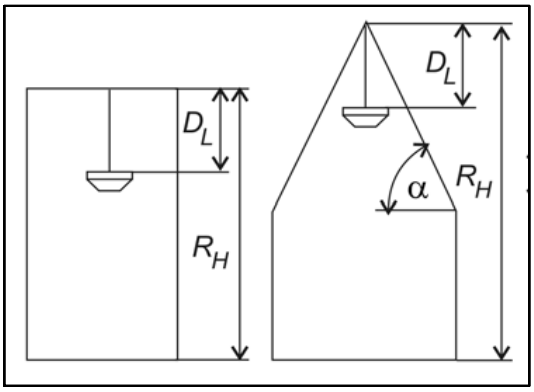


Fig.1. *Fire Detectors Arrangement Above Flat Roof And Slope Roof*(*Figure Source: Fire Protection Systems Designing, Milan Blagojević, Unpublished*)

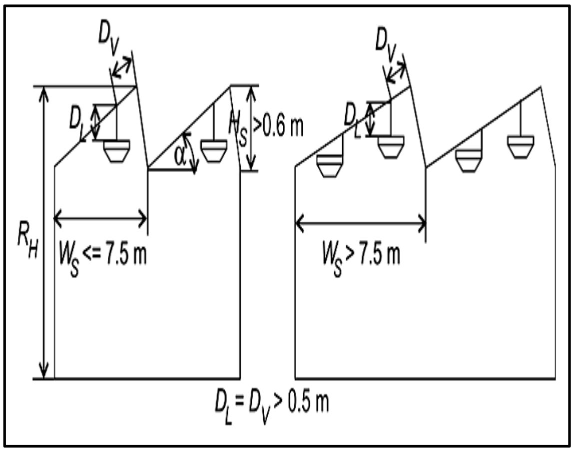


Fig.2. *Fire Detectors Arrangement In Case With Roofs With Several Slopes* (*Figure Source: Fire Protection Systems Designing, Milan Blagojević, Unpublished*)

The Aim Of This Paper Was To Show Simulation Results For Smoke Detectors Arrangement In The Case Of Slope Roof According To VDE 0832-2 Standard With Variations On Standard.

II. SIMULATION MODEL

Simulation Of Fire Process With Smoke And Flame Spreading Presents Great Way For

Research And Investigation Of Different Fire Situations At, What Is Very Important, Safe Way For Researcher And Their Surroundings. Simulation Model For This Paper Was Realized In FDS Software.This Software Was Based At The Fact That Fire Can Be Presented Numerically. This Software Presents Free Software, Developed By The National Institute Of Standards And Technology (NIST) Of The United States Department Of Commerce. The First Version Of This Program Was Published In 2000 And Since That Moment, There Were Several Versions Of This Software In The Last Several Years [13-17].

Simulation Model Used For This Paper Implied Objects With Dimensions 20 M X 30 M X 6 M, 20 M X 30 M X 8 M And 20 M X 30 M X 13 M. Every Single Object Was Realized With Roof Slope Smaller Than 20° And Roof Slope Bigger Than 20°. There Were Six Smoke Detectors In Every Object, Positioned At 0.25 M, 0.4 M And 0.6 M From The Top Of The Roof For Every Object`S Height (6m, 8m And 13m). This Was Done With Purpose, In Order To Realize Different Simulation Results, Although The Detector`S Distance From The Top Of The Roof, For Example, For Object With Dimensions 20 M X 30 M X 6 M And Slope Smaller Than 20° Distance From The Top Of The Roof (Marked As D_L On Figures 1 And 2) Was Maximal 0.25 M.

The Fire Source Was Modeled As Burner With Dimensions Of 0.85 M X 0.85 M And HRR (Heat Release Rate Per Area) Of Burner 500 Kw/M^2. The Burner's Position Was At The Left Corner For Every Object.The Activation Threshold Of Smoke Detectors Was 3,5 %/M Of Obscuration. The Examples Of Simulated Objects With Dimensions 20 M X 30 M X 6 M And Slope Smaller Than 20° , 20 M X 30 M X 8 M And Slope Bigger Than 20° And 20 M X 30 M X 13 M And Slope Bigger Than 20°, Every With Proper Smoke Detectors Arrangement Are Presented On Figures 3,4 And 5.

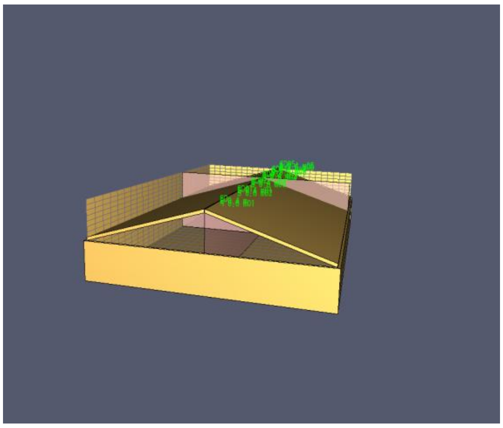


Fig. 3.*Object With Slope Roof, With Dimensions 20 M X 30 M X 6 M And Slope Smaller Than 20° And Proper Smoke Detectors Arrangement*

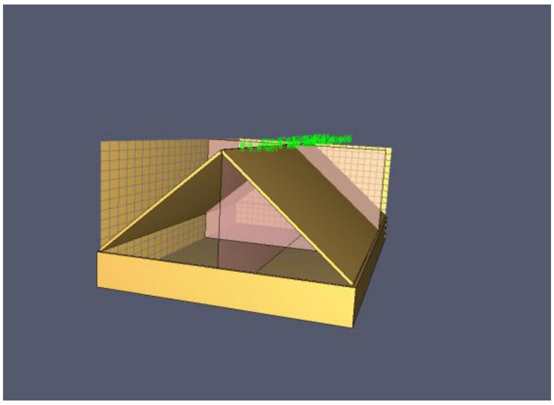


Fig. 4.*Object With Slope Roof, With Dimensions 20 M X 30 M X 8 M And Slope Bigger Than 20° And Proper Smoke Detectors Arrangement*

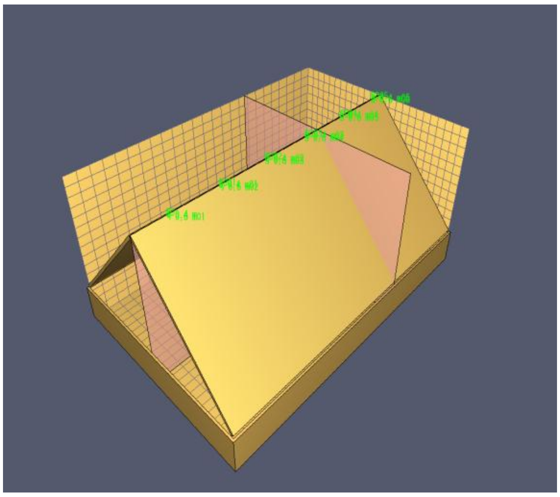


Fig. 5.*Object With Slope Roof, With Dimensions 20 M X 30 M X 13 M And Slope Bigger Than 20°And Proper Smoke Detectors Arrangement*

III. SIMULATION RESULTS

The Computer Used For Simulations Realized In This Paper Was Laptop LENOVO Ideapad 320-15IAP - 80XR00B5YA With Processor Intel® Pentium® N4200 Up To 2.50ghz, Screen Diagonal From 15.6", 500GB HDD And 4GB Of RAM Memory.The Simulation Time Was Set On 240 Seconds For Every Simulation.

Simulation Moments For Objects With Dimensions 20 M X 30 M X 6 M (A< 20°), 20 M X 30 M X 8 M (A< 20°) , 20 M X 30 M X 13 M (A> 20°) And 20 M X 30 M X 13 M (A< 20°) Are Presented On Figures From 6 To 14 While The Complete Simulation Realized Results Are Presented On Figure 15.

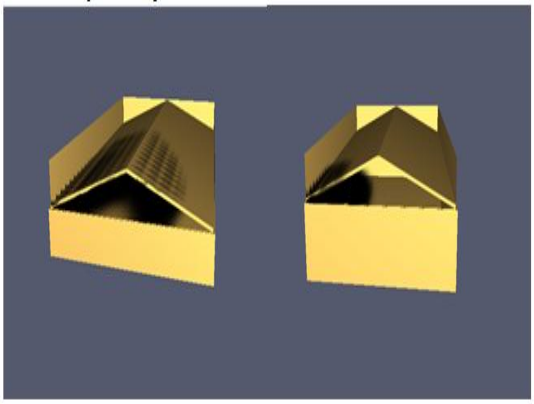


Fig.6. *Simulation Realized Results After22.1 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 6 M And Slope Smaller Than 20°*

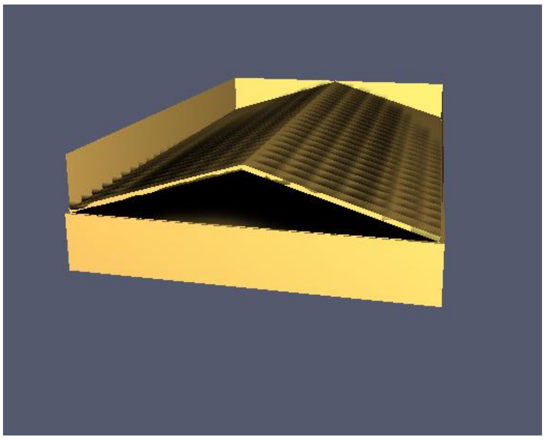


Fig.7. *Simulation Realized Results After46.1 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 6 M And Slope Smaller Than 20°*

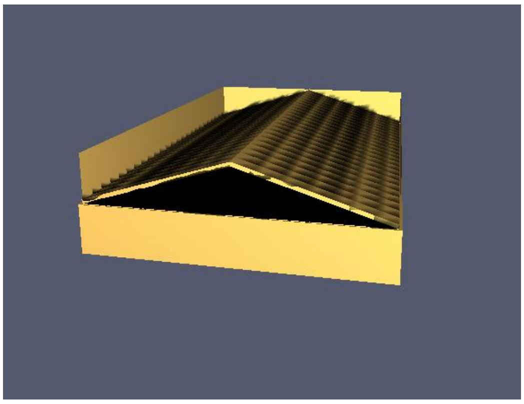
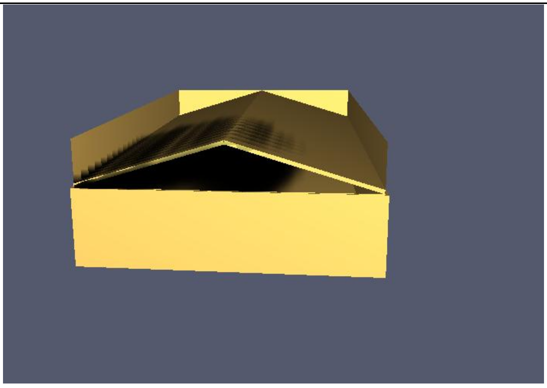


Fig.8. *Simulation Realized Results After191 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 6 M And Slope Smaller Than 20°*

Fig.9. *Simulation Realized Results After 9.8 Seconds After Simulation Start For Object With*



Dimensions 20 M X 30 M X 8 M And Slope Smaller Than 20°

Fig.10. *Simulation Realized Results After 20.7 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 8 M And Slope Smaller Than 20°*

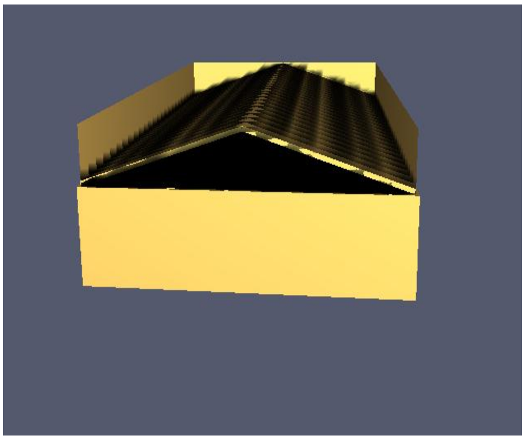


Fig.11. *Simulation Realized Results After 208.3 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 8 M And Slope Smaller Than 20°*

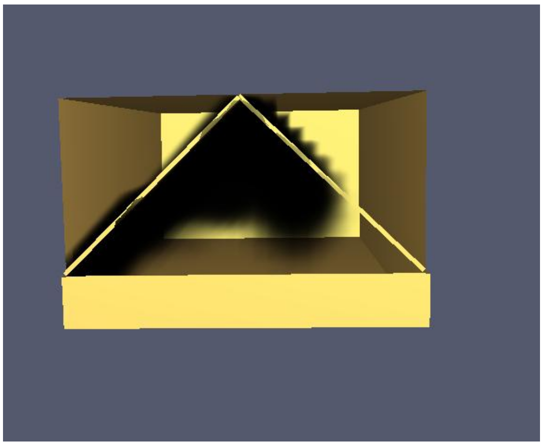


Fig.12. *Simulation Realized Results After24 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 13 M And Slope Bigger Than 20°*

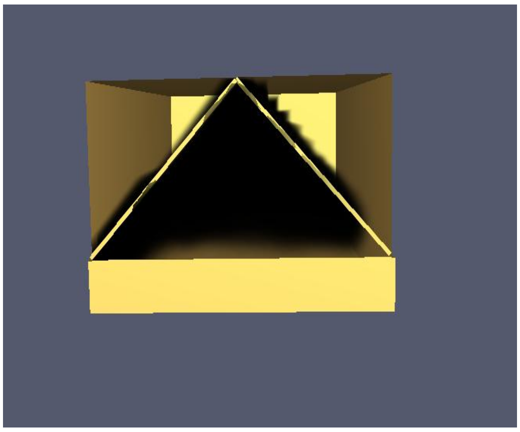


Fig.13. *Simulation Realized Results After 93.6 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 13 M And Slope Bigger Than 20°*

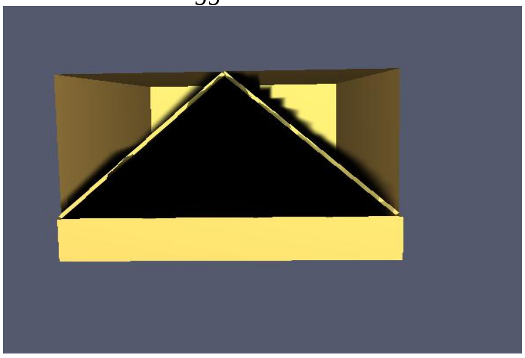


Fig.14. *Simulation Realized Results After 136 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 13 M And Slope Bigger Than 20°*

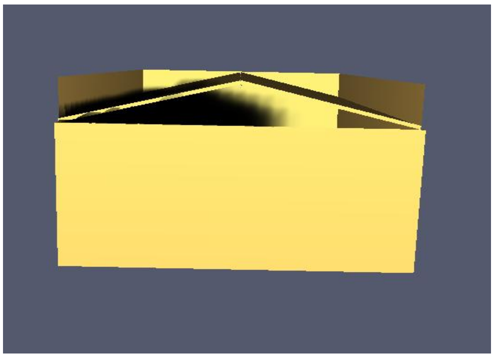


Fig.15. *Simulation Realized Results After 14.2 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 13 M And Slope Smaller Than 20°*

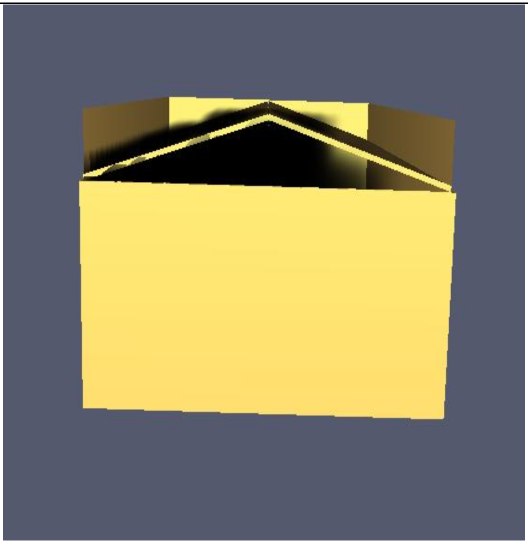


Fig.16. *Simulation Realized Results After 21.4 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 13 M And Slope Smaller Than 20°*

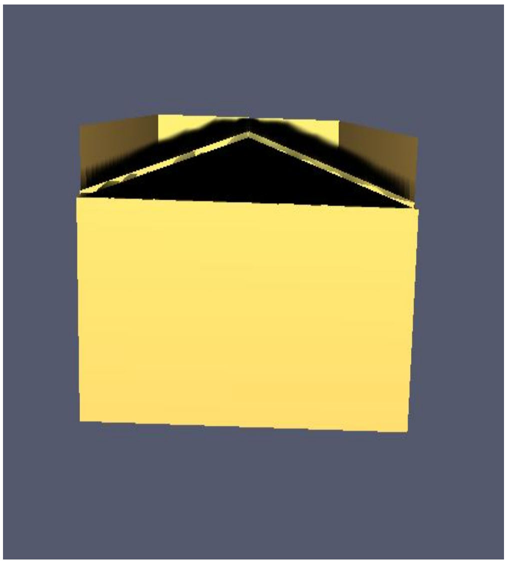


Fig.17. *Simulation Realized Results After 148.6 Seconds After Simulation Start For Object With Dimensions 20 M X 30 M X 13 M And Slope Smaller Than 20°*

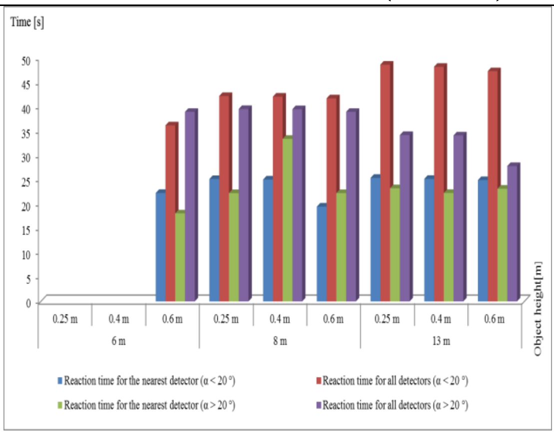


Fig.18.*The Complete Simulation Results For Objects With Dimensions 20 M X 30 M X 6 M, 20 M X 30 M X 8 M And 20 M X 30 M X 13 M. With Both Slopes Of Roofs (*A< 20°Andα> 20°*) And All Of Three Smoke Detector Distances From The Top Of The Roof (0.25 M, 0.4 M And 0.6 M)*

IV. ANALYSE OF RESULTS

Realized Simulations Showed Interesting Results. In Table 1, Smoke Detector Distance From The Top Of The Roof, For Object`S Height Up To 6 M (A< 20°)Was Maximal 0.25. Results Presented On Figure 18 Showed That For Object With That Height, For Smoke Distances From The Top Of The Roof For 0.25 M And 0.4 M, There Were No Any Reaction Of Positioned Smoke Detectors-Only For Smoke Detectors Positioned At 0.6 M From The Top Of The Roof What Is In Opposition With Referenced Standard Value. Similar Results Were Achieved For Object With The Same Height But Different Roof Slope (A> 20°).

The Shortest Reaction Time For One Smoke Detector Was Achieved For The Nearest Detector In Object With Height Of 6 M In Case For A> 20° And When The Distances Of Smoke Detectors From The Top Of The Roof Were 0.6 M. The Longest Reaction Time For All Smoke Detectors Was Achieved For Object With Height Of 13 M With Case For A< 20° And When The Distances Of Smoke Detectors From The Top Of The Roof Were 0.25 M.

V. CONCLUSION

The Limitations For This Paper Haven't Allowed Analyse Rules For Object With Slope Roofs Related To Some Other Standards. As It Was Noted, The Differences Do Exist Between Standards. For Example, European Standard EN-54-14, For Cases With Slope Roofs, Incites Rule That For Heat And Smoke Detectors Covering Radius Can Be Increased For 1% To Maximal 25 % For Every 1 ° Of Slope. American Standard NFPA 72 Contents References Simpler Than European Standard. British Standard BS Is Similar As EN-54 While Russian НПБ 88 Standard Doesn't Consider Fire Detectors Arrangement Above Slope Roofs.

Realized Results Once Again Confirmed The Importance Of Simulation Software Usage In Fire Protection And Showed That, Although Were Defined By Standards, Offered Values Should Be Considered From Case To Case, Especially In Cases Where Bigger Difference Between Standards Exists [18-21].

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