SYSTEMS FOR AUTOMATED BLAST DESIGN PLANNING AND METHODS RELATED THERETO

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 62/801,312, entitled "SYSTEMS FOR AUTOMATED BLAST DESIGN PLANNING AND METHODS RELATED THERETO," filed February 5, 2019, the contents of which are hereby incorporated herein by reference in their entirety.

Technical Field

[0002] The present disclosure relates generally to explosives. More specifically, the present disclosure relates to methods, systems and apparatuses for designing a blast plan.

Summary

[0002a] An aspect of the present disclosure provides a computer-implemented method for generating a blast plan, the method comprising:

receiving blast data comprising geometric and geological properties of a bench of a blast site to be blasted and a diameter and explosive properties of an available explosive product, wherein the geometric properties of the bench include a face height of the bench;

determining a pattern footage representing an area capable of being properly fragmented by the available explosive product in a blasthole located in the bench, wherein determining the pattern footage comprises determining a relationship between the face height, the specific energy of the available explosive product, and the geological properties of the bench;

determining a burden and a spacing from the pattern footage; and

generating a blast plan using the burden and the spacing.

[0002b] Another aspect of the present disclosure provides a system for generating a blast plan, the system comprising:

a memory device to store blast data comprising blast site dimensions, blast site geology, and available explosive types;

a processing unit to:

receive blast data comprising geometric and geological properties of a bench of a blast site to be blasted and a diameter and explosive properties of an available explosive product, wherein the geometric properties of the bench include a face height of the bench;

determine a pattern footage representing an area capable of being properly fragmented by the available explosive product in a blasthole located in the bench, wherein determining the pattern footage comprises determining a relationship between the face height, the specific energy of the available explosive product, and the geological properties of the bench;

determine a burden and a spacing from the pattern footage; and

generate a blast plan using the burden and the spacing.

~~**[0002b]** Another aspect of the present disclosure provides a method for generating a blast plan, the method comprising:~~

~~receiving blast data comprising blast site dimensions, blast site geology, and available explosive product types;~~

~~generating a dataset comprising a plurality of permutations of the received blast data;~~

~~simulating a blast for each of the plurality of permutations to determine a plurality of simulated results; and~~

~~generating a blast plan based on a top scoring simulated result, wherein the blast plan identifies location of blastholes to be drilled and type and quantity of explosive to be used.~~

~~**[0002c]** Another aspect of the present disclosure provides a system for generating a blast plan, the system comprising:~~

~~a memory device to store blast data comprising blast site dimensions, blast site geology, and available explosive types;~~

~~a processing unit to:~~

~~generate a dataset comprising a plurality of permutations of the blast data;~~

~~determine spacing and burden for each of the plurality of permutations that results in a smallest overflow or underflow of holes on a blast site, wherein the spacing and burden is based on an explosive type for each of the plurality of permutations and the blast site geology;~~

~~validate that a blast for each of the plurality of permutations using the determined spacing and burden meets a set of blast criteria;~~

~~score characteristics of the validated blasts for each of the plurality of permutations; and~~

~~generate a blast plan based on a top scoring validated result, wherein the blast plan identifies location of blastholes to be drilled and type and quantity of explosive to be used.~~

~~**[0002d]** Another aspect of the present disclosure provides a method for generating a blast plan, the method comprising:~~

~~receiving blast data comprising blast site dimensions, blast site geology, and available explosive types;~~

~~generating a dataset comprising a plurality of permutations of the received blast data;~~

~~determining a plurality of spacing and burden configurations for each of the plurality of permutations based on an explosive type for each of the plurality of permutations and the blast site geology;~~

~~simulating a blast for each of the plurality of permutations and determining which of the plurality of spacing and burden configurations for each of the plurality of permutations~~

~~meets a target blast criteria with an absolute remainder that is smaller than any other absolute remainders associated with other spacing and burden configurations; and~~

~~generating a blast plan based on simulated results.~~

Brief Description of the Drawings

[0003] The embodiments disclosed herein will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. The drawings depict primarily generalized embodiments, which embodiments will be described with additional specificity and detail in connection with the drawings in which:

[0004] FIG. 1 illustrates a network diagram of a blast plan modeling system according to one embodiment.

[0005] FIG. 2 illustrates a personal electronic device displaying a scanning path of a drone according to one embodiment.

[0006] FIG. 3 illustrates a block diagram of a blast design system according to one embodiment.

[0007] FIG. 4 illustrates a flow chart of a method for generating a blast design according to one embodiment.

[0008] FIG. 5 illustrates a flow chart of a method for generating a blast design by executing multiple simulations for a plurality of possible permutations according to one embodiment.

[0009] FIG. 6 illustrates an example of a method of generating a dataset of a plurality of permutations from blast data according to one embodiment.

[0010] FIG. 7 illustrates an example of a method for simulating the permutations of the dataset according to one embodiment.

[0011] FIG. 8A illustrates a first part of a method for generating blast level details according to one embodiment.

[0012] FIG. 8B illustrates a second part of a method for generating blast level details according to one embodiment.

[0013] FIG. 9 illustrates a method for finding a prioritized distance that fits on the blast site according to one embodiment.

[0014] FIG. 10 illustrates a method for generating hole level details for a given burden and space according to one embodiment.

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Claims

1. A computer-implemented method for generating a blast plan, the method comprising:

receiving blast data comprising geometric and geological properties of a bench of a blast site to be blasted and a diameter and explosive properties of an available explosive product, wherein the geometric properties of the bench include a face height of the bench;

determining a pattern footage representing an area capable of being properly fragmented by the available explosive product in a blasthole located in the bench, wherein determining the pattern footage comprises determining a relationship between the face height, the specific energy of the available explosive product, and the geological properties of the bench;

determining a burden and a spacing from the pattern footage; and

generating a blast plan using the burden and the spacing.

2. The method of claim 1, wherein determining the pattern footage comprises calculating a geometric relationship of the face height to a diameter of the available explosive product, specific to the geological properties of the bench, to determine a raw pattern footage.

3. The method of claim 1, wherein determining the pattern footage comprises inputting a ratio of the face height to the diameter of the available explosive product as a variable into an equation with geological constants empirically fit to prior blast data from previous blasts that resulted in proper fragmentation of the particular bench material of the previous blasts to determine a raw pattern footage.

4. The method of claim 3, wherein the prior blast data includes actual explosive loaded data from site equipment used to load explosives in boreholes in the previous blasts.

5. The method of any one of claims 3-4, wherein determining the pattern footage further comprises modulating the raw pattern footage based on differences between the specific energy of the available explosive product and the explosive product used in the previous blasts from which the prior blast data was used in generating the equation.

6. The method of any one of claims 2-5, wherein determining the pattern footage further comprises modulating the raw pattern footage based on the volume of the available explosive product.

7. The method of claim 1, wherein determining the pattern footage comprises defining an area around holes in a blast plan, wherein the pattern footage comprises a product of a first factor based on the geological properties and the face height, a second factor based on the specific energy of the available explosive product, and a third factor based on a diameter of the available explosive product.

8. The method of claim 7, further comprising calculating the first factor by:

calculating a result of multiplying a first geological factor by the natural log of a dividend of a face height divided by the diameter of the available product; and

reducing the result by a second geological factor.

9. The method of any one of claims 7-8, further comprising calculating the third factor by dividing the diameter by a measuring unit factor, and squaring a resulting dividend.

10. The method of any one of claims 7-9, wherein determining the burden further comprises multiplying the square root of the pattern footage by a constant derived from a rock class from the geological properties of a blast site.

11. The method of any one of claims 1-10, wherein the geological properties of a blast site comprise rock density, rock type, rock strength, attenuation characteristics or combinations thereof; and

the method~~s~~ further comprising receiving blasthole parameters comprising the face height, desired blast pattern type, likelihood and/or potential amount of water in any blastholes drilled, and a diameter of an available drill; and

receiving information on the available explosive product comprising the type of the available explosive product, the weight and/or volume of the available explosive product as deliverable to the blast site, weight of material to be blasted, volume of material to be blasted, and number of holes that can be filled by the available explosive product as deliverable to the blast site.

12. The method of any one of claims 1-11 wherein the blasthole parameters comprise a desired blast pattern type, and wherein the constant is further derived based on a shape of the desired blast pattern type.

13. The method of any one of claims 1-12, wherein the blast plan comprises the burden and the spacing.

14. The method of any one of claims 1-13, further comprising generating a dataset comprising a plurality of permutations of the received blast data; and

simulating a blast for each of the plurality of permutations to determine a plurality of simulated results,

wherein the blast plan is based on a top scoring simulated result.

15. A system for generating a blast plan, the system comprising:

a memory device to store blast data comprising blast site dimensions, blast site geology, and available explosive types;

a processing unit to:

receive blast data comprising geometric and geological properties of a bench of a blast site to be blasted and a diameter and explosive properties of an available explosive product, wherein the geometric properties of the bench include a face height of the bench;

determine a pattern footage representing an area capable of being properly fragmented by the available explosive product in a blasthole located in the bench,

wherein determining the pattern footage comprises determining a relationship between the face height, the specific energy of the available explosive product, and the geological properties of the bench;

determine a burden and a spacing from the pattern footage; and

generate a blast plan using the burden and the spacing.

~~15. A method for generating a blast plan, the method comprising:~~

~~receiving blast data comprising blast site dimensions, blast site geology, and available explosive product types;~~

~~generating a dataset comprising a plurality of permutations of the received blast data;~~

~~simulating a blast for each of the plurality of permutations to determine a plurality of simulated results; and~~

~~generating a blast plan based on a top scoring simulated result, wherein the blast plan identifies location of blastholes to be drilled and type and quantity of explosive to be used.~~

~~16. The method of claim 15, wherein simulating the blast for each of the plurality of permutations comprises determining a pattern footage based on an explosive type for a permutation and the blast site geology.~~

~~17. The method of claim 16, wherein simulating the blast for each of the plurality of permutations further comprises determining an initial burden and an initial spacing based on the pattern footage.~~

~~18. The method of claim 17, wherein the initial burden is $C \times \sqrt{\text{the pattern footage}}$, where C is a constant derived from the rock class, and wherein the initial spacing is $\frac{\text{the pattern footage}}{\text{the initial burden}}$.~~

~~19. A system for generating a blast plan, the system comprising:~~

~~a memory device to store blast data comprising blast site dimensions, blast site geology, and available explosive types;~~

~~a processing unit to:~~

~~generate a dataset comprising a plurality of permutations of the blast data;~~

~~determine spacing and burden for each of the plurality of permutations that results in a smallest overflow or underflow of holes on a blast site, wherein the spacing and burden is based on an explosive type for each of the plurality of permutations and the blast site geology;~~

~~validate that a blast for each of the plurality of permutations using the determined spacing and burden meets a set of blast criteria;~~

~~score characteristics of the validated blasts for each of the plurality of permutations; and~~

~~generate a blast plan based on a top scoring validated result, wherein the blast plan identifies location of blastholes to be drilled and type and quantity of explosive to be used.~~

~~20. The system of claim 19, further comprising a drone comprising a camera, the drone to capture images of the blast site.~~

~~21. The system of any one of claims 19-20, wherein the processing unit is further to:~~

~~receive post-blast images of the blast site;~~

~~perform post-blast analysis on the post-blast images to identify debris sizing and debris spread.~~

~~22. A method for generating a blast plan, the method comprising:~~

~~receiving blast data comprising blast site dimensions, blast site geology, and available explosive types;~~

~~generating a dataset comprising a plurality of permutations of the received blast data;~~

~~determining a plurality of spacing and burden configurations for each of the plurality of permutations based on an explosive type for each of the plurality of permutations and the blast site geology;~~

~~simulating a blast for each of the plurality of permutations and determining which of the plurality of spacing and burden configurations for each of the plurality of permutations meets a target blast criteria with an absolute remainder that is smaller than any other absolute remainders associated with other spacing and burden configurations; and~~

~~generating a blast plan based on simulated results.~~

~~23. The method of claim 22, wherein the absolute remainder is determined by dividing the spacing or the burden by one of the blast site dimensions.~~

~~24. The method of any one of claims 22-23, further comprising:~~

~~scoring the plurality of simulated results; and~~

~~generating the blast plan based on a top scoring simulated result.~~

~~25. The method of claim 24, wherein the scoring the plurality of simulated results is based on one or more of cost, number of decks, number of holes, burden stiffness ratio, and vibration score.~~

~~26. The method of any one of claims 22-25, further comprising varying the explosive type within the plurality of permutations.~~