A UNIFIED THEORY FOR STRESSES AND OSCILLATIONS

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1. INTRODUCTION

The aim of the paper is to introduce a unified theory for stresses and oscillations. The stresses developed on a particle due to various forces are classified as: i) fundamental stresses; ii) internal stresses; and iii) external stresses. The fundamental stresses are developed due to presence of gravitational and electromagnetic forces of a solar system. The internal stresses are developed under the influence of fundamental stresses and are defined by properties of composition of a particle. The external stresses are developed under an external source of energy. The oscillations of a particle are assumed to be generated because of stress development with cyclic load of day/night, heating/cooling and compression/expansion.

1. 1. Free body analysis

In order to support this hypothesis, a full scale experimental setup for an external photovoltaic cavity wall was installed in an outdoor room facility located at Concordia University, Montréal, Canada (Dehra, 2004). The free body diagram showing energy balance of major composite loads acting on system of a photovoltaic cavity wall is illustrated in Fig. 1. The photovoltaic cavity wall was an amplifier, constituting of a parallel plate photovoltaic device connected to a potentiometer. The cavity wall was constructed with a pair of glass coated photovoltaic (PV) modules forming a parallel plate duct with a plywood board and connected to a potentiometer. A potentiometer, a wire-wound variable resistor of up to 50 Ω was a wire-wound circular coil with a sliding knob contact (Dehra, 2004). It was used to vary electrical resistance across connected PV modules without interrupting the current.

The various forces acting on a photovoltaic cavity wall system were identified. The gravitational force (Mg) act on mass of photovoltaic cavity wall system. The short wave electromagnetic force was applied on a photovoltaic cavity wall due to rotation and movement of the Earth around the Sun. The day/night on the Earth's surface causes periodic force of solar intensity (S) incident on surface of photovoltaic module. Electricity (E) was generated from a photovoltaic module under the influence of gravitational force of the Earth and electromagnetic force of the solar system, which results in generation of electricity due to incident sunlight on electrical system of photovoltaic module. The unutilized absorbed solar radiation was dissipated as electrical noise from a solid state device of photovoltaic module, which results in generation of heat (H). The generated heat was exchanged with the surrounding environmental system by modes of heat conduction, convection and radiation. The long wave radiation heat exchange occurs between photovoltaic module and plywood board. The heat storage was due to heat storage elements in photovoltaic cavity wall. The major heat storage was due to polystyrene filled plywood wall. Thermal force (T) was developed because of energy dissipation in the vertical and horizontal members from thermal system of photovoltaic cavity wall. Thermal storage was due to thermal storage elements in photovoltaic cavity wall. The major thermal storage was due to glass coated semi conductor material of photovoltaic module. The combination of thermal force and heat exchange has resulted in heating/cooling load on thermal-fluid system of photovoltaic cavity wall. The combination of thermal force and heating/cooling load results in compression/expansion load on structural system of photovoltaic cavity wall. The ambient air entering into ventilation system of photovoltaic cavity wall was set in motion due to differences in temperature between walls of cavity wall and that of air entering into cavity wall.

The enhancement in air flow rate through a cavity wall was achieved by means of an external source of energy of an exhaust fan-induced velocity (EF). The enhancement in air flow rate of ventilation system of photovoltaic cavity wall was also achieved in presence of wind force (WF) applied on photovoltaic cavity wall. The internal sound force (ISF) was generated in photovoltaic cavity wall due to air velocities of wind and fan. The external sound force (ESF) was also applied on sound insulation system of photovoltaic cavity wall due to sound propagation from the surrounding environmental system of photovoltaic cavity wall.

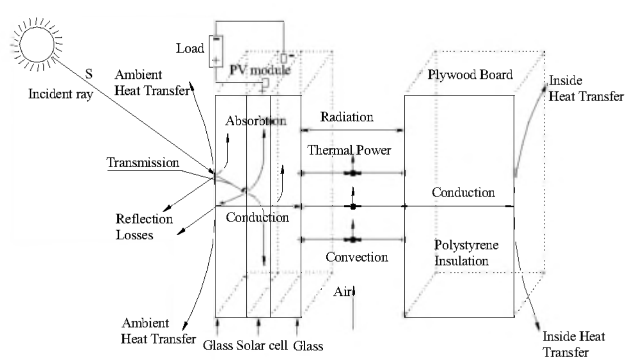


Fig. 1. Free body diagram of major composite loads acting on a photovoltaic cavity wall

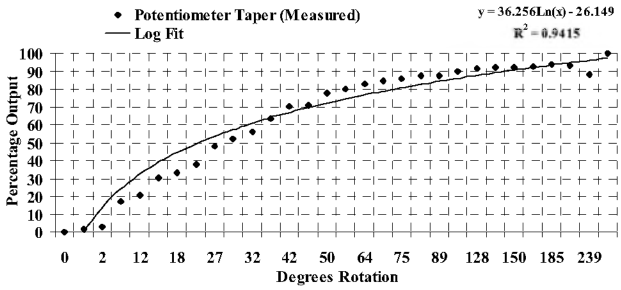
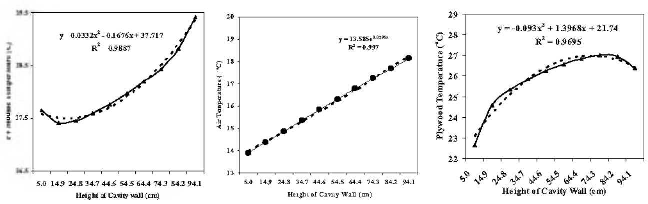


Fig. 2. Potentiometer Taper (Measured) with percentage voltage output



(a) (b) (c)

Fig. 3. Temperature plots with height of PV cavity wall: (a) PV module; (b) air; and (c) plywood board

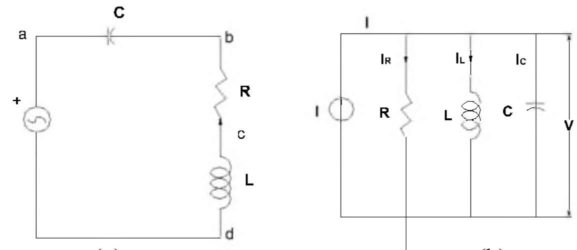
2. AMPLIFICATION RESULTS

The characteristics of a parallel plate photovoltaic device connected to a potentiometer were established by varying electrical resistance with rotation of knob of a potentiometer (Dehra, 2004). The current-voltage measurements were obtained for determining electric power output with a series electrical circuit connection of a pair of vertically inclined PV modules installed on a wooden frame. The results of the power output from a potentiometer with rotation of circular knob are illustrated in Fig. 2.

A mathematical model for prediction of temperature distributions varying with volume of a parallel plate photovoltaic device was developed (Dehra, 2004). The model is used to predict temperature distributions at pre-defined locations in PV module, plywood board and air flowing through a cavity wall based on input measurement data of solar intensity, air velocity and ambient and room air temperatures. The results of the temperature plots are illustrated from Fig. 3 (a) to Fig. 3 (c).

3. DISCUSSIONS

The amplification results of the graphs of Figs. (2) and (3) show that the gain in steady state electrical and thermal functions for a photovoltaic cavity wall is a factor of its volume or resistance. The electrical analog is used herewith to illustrate the resonance phenomenon at amplification for equivalent mechanical, hydraulic and thermal systems for a parallel plate photovoltaic cavity wall, which was connected to a potentiometer. The two cases of series and parallel L-C-R circuit resonance are illustrated in Fig. 4.



(a) (b)

Fig. 4. (a) L-C-R series arrangement of resonance; (b) L-C-R parallel arrangement of resonance

The cases of resonance are visualised at occurrence of phenomenon of photovoltaic amplification. Inductance is mass for the mechanical system for propagation of elastic waves. Capacitance is heat storage capacities of photovoltaic modules, air and polystyrene filled plywood board. Polystyrene filled plywood board is vulnerable to fire as soon as heat waves propagated with frequency matching with its latent heat of vaporisation is reached. Resistance is developed due to electrical, thermal and fluid resistance in energy storage elements of photovoltaic modules, air and polystyrene filled plywood board. The series case of L-C-R resonance occurs with power transfer due to elastic waves and electricity transmission from a photovoltaic cavity wall. The parallel case of L-C-R resonance occurs with power transfer due to electricity, heat waves (C-R) and fluid surface waves (C-R) in conjunction with inductance (L) due to mass of photovoltaic cavity wall and resistance (R) due to temperatures of ground surface and ambient air.

4. CONCLUSION

A unified theory for stresses and oscillations is introduced with an example of an external cavity wall made up of a parallel plate photovoltaic device. The theory has discussed the propagation of acoustic waves caused due to various stresses and oscillations of a cavity wall. The theory is eligible for defining new criteria for generation of acoustic resonance to include waves propagated with transmission of light, sound, noise, heat, electricity, fluid and fire from a cavity wall. A mathematical model has been formulated for the theory based on field experiments conducted on a cavity wall with one degree of freedom.

REFERENCES

Dehra, H. (2004). A numerical and experimental study for generation of electric and thermal power with photovoltaic modules embedded in building façade, *submitted/unpublished Ph.D. thesis*, Department of Building, Civil and Environmental Engineering, Concordia University, August 2004.