BEHAVIOR OF NON-STRUCTURAL MATERIALS ON FIRE- PLASTICS, GLASS, TEXTILE FIBRES AND OTHER HOUSE HOLD MATERIALS.

The behavior of non-structural materials during a fire varies widely depending on their composition and properties. Here's an overview of how plastics, glass, textile fibers, and other common household materials behave when exposed to fire, including some derivations where relevant.

1. Plastics

Plastics are a diverse group of materials with different fire behaviors based on their chemical compositions. Here's a summary of their general behavior:

a) **Combustion Characteristics:**

i. **Low-Density Polyethylene (LDPE):** LDPE has a low ignition temperature (~300°C) and burns with a yellow flame. It releases toxic gases such as carbon monoxide and hydrogen cyanide.

ii. **Polyvinyl Chloride (PVC):** PVC has a higher ignition temperature (~400°C) and tends to release hydrochloric acid (HCl) when burned, which is corrosive and harmful.

b) **Heat Release Rate:** The rate at which heat is released during combustion can be estimated by:

$$Q = m \cdot \Delta H$$

Where:

- Q is the heat released,
- m is the mass of the plastic,
- ΔH is the heat of combustion of the plastic.

For example, the heat of combustion for LDPE is approximately 47 MJ/kg. The actual heat release rate (HRR) depends on the burning conditions and can be influenced by factors like ventilation.

c) **Thermal Degradation:** Plastics decompose when exposed to high temperatures. The decomposition temperature (T_d) can be estimated from thermal gravimetric analysis (TGA), which provides the weight loss as a function of temperature.

For instance:

$$\text{Decomposition rate} = \frac{d(\text{Weight})}{dT}$$

This gives a measure of how quickly a plastic loses mass as temperature increases.

2. Glass

a) **Thermal Stability:** Glass generally has high thermal stability and does not burn. However, it can undergo thermal stress and potentially break or shatter when exposed to rapid temperature changes.

b) **Thermal Expansion:** Glass expands with heat, and the coefficient of thermal expansion (CTE) is typically around 8×10^{-6} per °C. The change in volume due to temperature change (ΔT) can be calculated by:

$$\Delta V = V_0 \cdot \alpha \cdot \Delta T$$

Where:

- V_0 is the original volume,
- α is the coefficient of thermal expansion (CTE),
- ΔT is the temperature change.

In fire conditions, the differential thermal expansion between glass and its frame or In fire In fire conditions, the differential thermal expansion between glass and its frame or surrounding materials can lead to cracking or failure.

3. Textile Fibers

a) **Natural Fibers (e.g., Cotton, Wool):**

i. **Cotton:** Burns easily and rapidly at temperatures above 200°C. It leaves behind a significant amount of ash and may emit smoke and gases.

ii. **Wool:** Has a higher ignition temperature (~600°C) compared to cotton and is more resistant to burning. Wool is often treated with flame retardants to improve its fire resistance.

b) **Synthetic Fibers (e.g., Polyester, Nylon)**

i. **Polyester**: Melts rather than burns at about 250°C. It produces a plastic-like residue and can drip, which may contribute to the spread of fire.

ii. **Nylon:** Melts and chars at around 300°C. It releases toxic fumes like carbon monoxide and hydrogen cyanide.

c) **Decomposition:** The decomposition of textile fibers can be modeled using thermogravimetric analysis (TGA), where the rate of mass loss is related to temperature. The degradation temperature (T_d) can be represented as:

$$\text{Decomposition rate} = \frac{d(\text{mass})}{dT}$$

4. Other Household Materials:

a) **Wood:** Wood typically ignites at temperatures around 300-400°C. It undergoes pyrolysis, where it decomposes into volatile gases and charcoal. The combustion of wood can be approximated by:

$$Q = m \cdot \Delta H$$

Where, ΔH is the heat of combustion, approximately 15-20 MJ/kg for wood.

b) **Paper:** Paper ignites at around 230°C and burns quickly. It produces a lot of smoke and releases carbon dioxide and monoxide.

c) **Rubber:** Rubber materials (like tires) have complex combustion behaviors. They can start burning at around 300°C and produce significant smoke and toxic gases.

Summary: Understanding the fire behavior of non-structural materials is crucial for fire safety and protection. Plastics may release toxic gases and burn rapidly, while glass is more stable but can shatter under thermal stress. Textile fibers vary widely in their fire resistance, with natural fibers burning more readily than synthetics. Other materials like wood, paper, and rubber each have specific combustion characteristics that affect how they contribute to fire behavior in household environments.