

Design Research Seminar

Consideration of social behavior of women workers while designing a **dust protection face mask**, to be used in a highly dusty environment.

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Guide:
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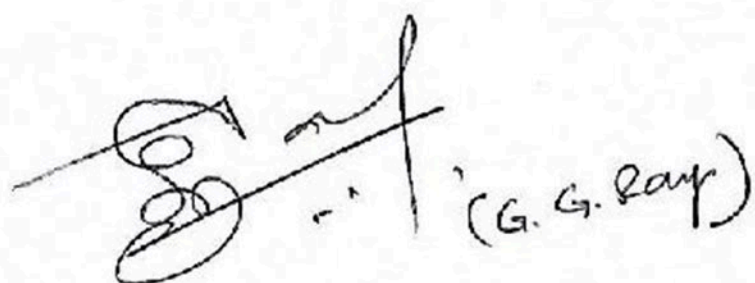


IDC School of Design
IIT Bombay

Approval

The project titled '**Consideration of social behavior of women workers while designing a dust protection face mask, to be used in a highly dusty environment**' by Apurba Mondal is approved in the partial fulfillment of the requirements for Master of Design Degree in Industrial Design.

Guide:

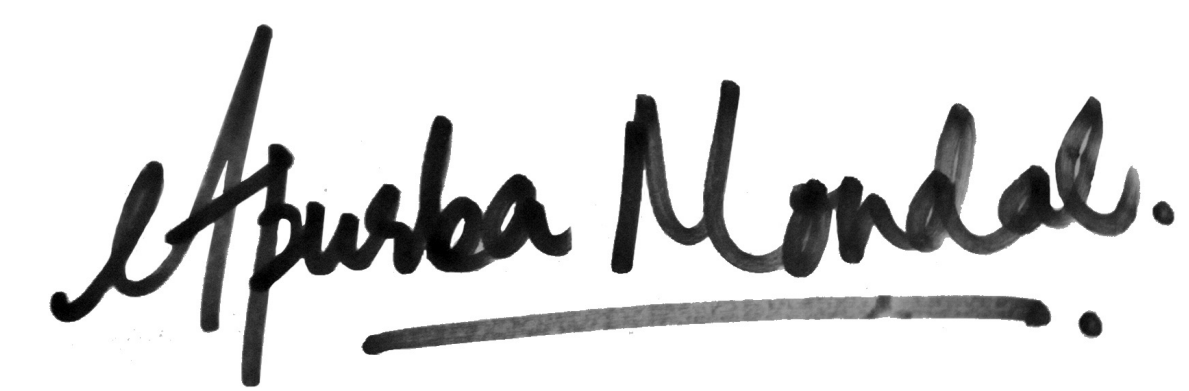
A handwritten signature in black ink, appearing to be 'G. G. Ray', written over a horizontal line.

Date:

July 25, 2019

Declaration

I hereby declare that the research work done, ideations and concepts done in the submission are original and appropriate citations have been provided wherever due. I understand that the violation of the above can cause disciplinary action by the institute.

A handwritten signature in black ink that reads "Apurba Mondal." The signature is written in a cursive style with a horizontal line underneath the name.

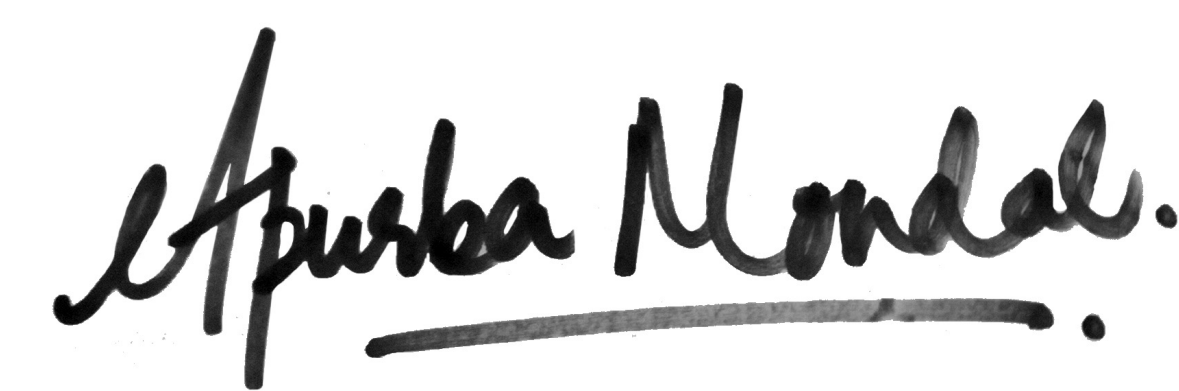
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I would like to thank my family and friends for motivating me and supporting through the period of the project.

A handwritten signature in black ink, reading 'Apurba Mondal' with a horizontal line underneath the name.

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Abstract

India is world's second largest producer of bricks with over 200 million bricks manufactured a year in the 100,000 units across the country where 65 percent of it gets manufactured in the Indo-Gangetic plains. The workers in the unorganized brick making sector are most vulnerable to physical, economical and mental exploitations with no systematic record of them.

Fixed Chimney Bull-Trenches and the Clamp are the two types of kilns which are used in India which have higher black carbon and dust emissions compared to the Hoffman kilns being used in China. The paper focuses on the workplace related hazards faced by the workers which results in respiratory disorders and to create design interventions in the clothing of the female workers with and without the usage of standard filter fabrics which would be socially accepted by the workers.



Figure 1: Workers in Uttar Pradesh

<https://www.thethirdpole.net/en/2016/06/20/controversy-over-how-indian-brick-kilns-clean-up-their-act/>

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Introduction

From a study done by the third pole, almost all brick moulders are from minority groups and belong to traditionally marginalised/ excluded castes and classes. In break-down, 35% were Scheduled Caste (Dalits), 35% were 'Other Backward Classes' (marginalised socio-economic class) and Adivasis - 30%. The daily work hours of the workers is about 14 in Summers and 11 hours in Winter period.

There is a gap in the knowledge of worker about their labour rights. Most workers do not know what the minimum wage limit is for 1000 bricks. Almost 96% of the Men take advanced loans before joining the unit and are kept for more than the period promised. Situation of the women is worse as they do not receive the salary to their work directly but instead the income is paid on a family basis to the eldest male in the household. The amount paid to the women is comparatively less compared to men.

There is lack of provision of safety equipments, housing facilities and there is a lack of clean water provision and sanitation in the kiln worker settlements.



Figure 4: Workers at Diamond Harbour, West Bengal



Figure 2: Workers in Western Uttar Pradesh



Figure 3: Brothers working in Koltaka, West Bengal

Preliminary Research

Health and Safety Issues

There are healthcare schemes but less than 10 percent of the workers benefit from them. The retirement age for this industry is less than 40 years where the employees end up suffering from incurable diseases throughout their lives.

- Workers get exposed to the flying ashes of bricks as they do not get a formal or informal training and safety equipment are not provided such as a mask when they carry baked bricks from the chimney.
- The firemen light the fire in the chimney for the baking bricks and continuously monitor it without proper shoes, masks and other safety equipments.
- The workers suffer from Musculoskeletal pain, dehydration, headaches, chest pain, skin rashes and malnourishment.
- There is a high risk of infection arising from the lack of sanitation services around the kilns.

The worker groups most affected by the dust particles are the Nikashi or the Pakkareja's who take out the fired bricks from the kiln and transport it using wheelbarrows. There is a dense cloud of dust which falls on their body while carrying. Another group is the cleaning group called the Rab-bishman who cover the top of the kiln with dust to seal the heat when the coal starts burning. They also have the responsibility to clean the top of the kilns and the insides when the bricks are needed to be removed after firing.

The major particulate matters which are in these kilns are:

Silica:

One of the more dangerous traits of respirable crystalline silica (RCS) is the extremely small particle size, which allows them to stay in the air for longer and get indoors. According to NIEHS (National Institute of Environmental Health Services), the size of dust emissions from silica-containing substances varies from $.01\mu\text{m}$ to $100\mu\text{m}$ in diameter.

Alumina:

Particle size ranges from 48, 12 and $3\mu\text{m}$. The particles cause dry eye, irritation in the eyes and skin. Ingestion of large amounts may cause gastrointestinal irritation but it has a low hazard if consumed or ingested. The particles may also cause respiratory tract irritation and lung damage.

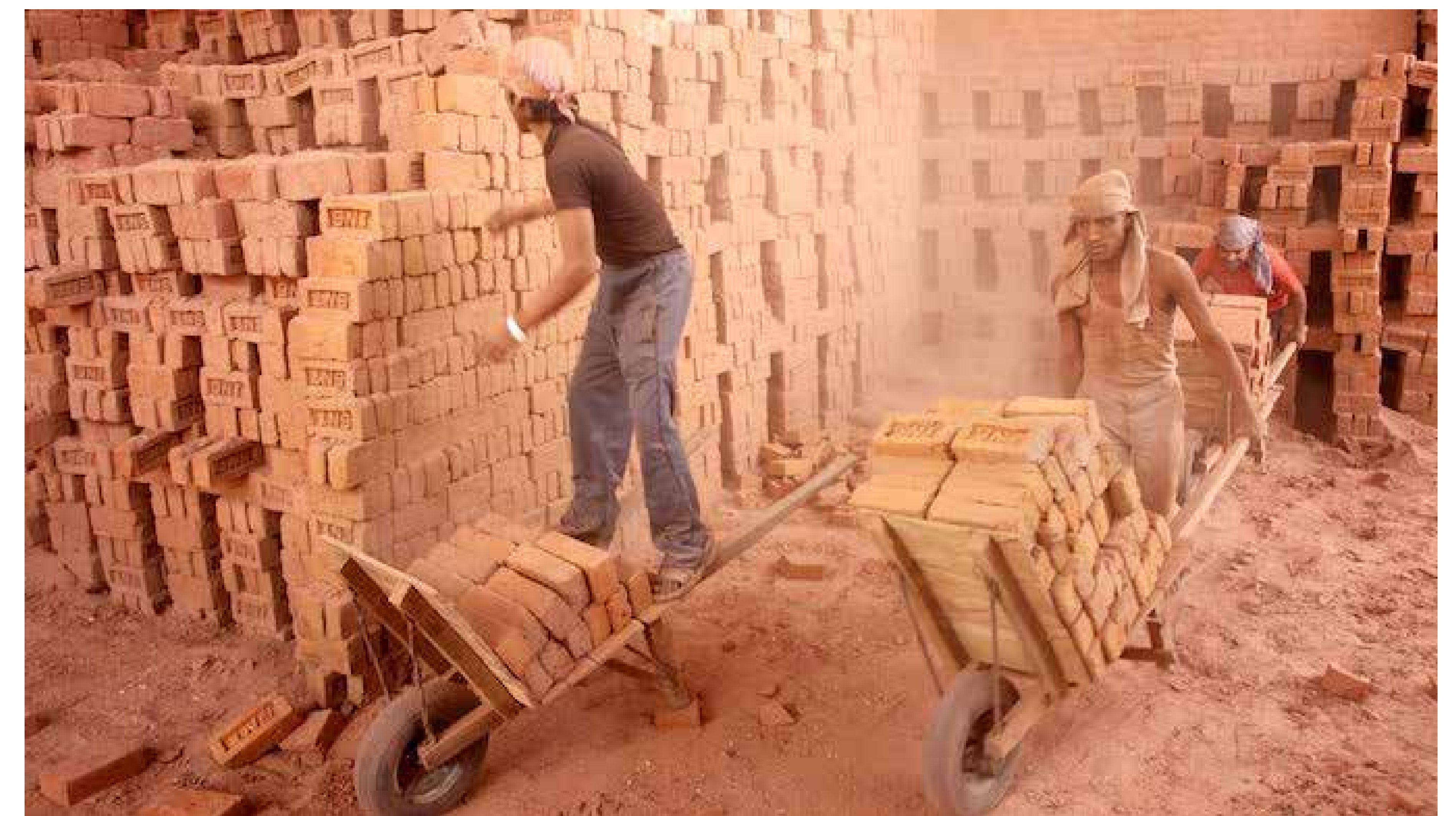


Figure 4: Nikashi's at work.

What happens when we breathe dust?

The lungs are protected by a series of defense mechanisms in different regions of the respiratory tract. Most of the bigger particles that enter the airways are expelled out from the body through mucus while sneezing and coughing. The particles that make through to the air passage, they enter the tubes called bronchi and bronchioles. Mucus is generated by the cells that line the passageway. Tiny hairs called cilia, covering the walls of the air tubes, move the mucus upward and out into the throat, where it is either coughed up and spat out, or swallowed.

The air reaches the tiny air sacs (alveoli) in the inner part of the lungs which fail to be stopped by the upper airways. The exchange of oxygen and carbondioxide happen in these air sacs. Dust that reaches the sacs and the lower part of the airways where they are attacked by special cells called macrophages. These cells keep the air sacs clean and eventually swallow the particles. The cells capture the particles and due to their wave like motion in the air passages move up to the mouth and throat and are expelled via cough, sneeze and saliva.

Besides macrophages, the lungs have another system for the removal of dust. The lungs can react to the presence of germ-bearing particles by producing certain proteins. These proteins attach to particles to neutralize them. But many particles like silica, alumina and other chemicals reach the ends of the sacs and are difficult to remove and hence get permanently deposited and stop the exchange of oxygen and Carbondioxide. If the particle attacks the larger air passages, inflammation of the trachea (**tracheitis**) or the bronchi (**bronchitis**) may be seen.

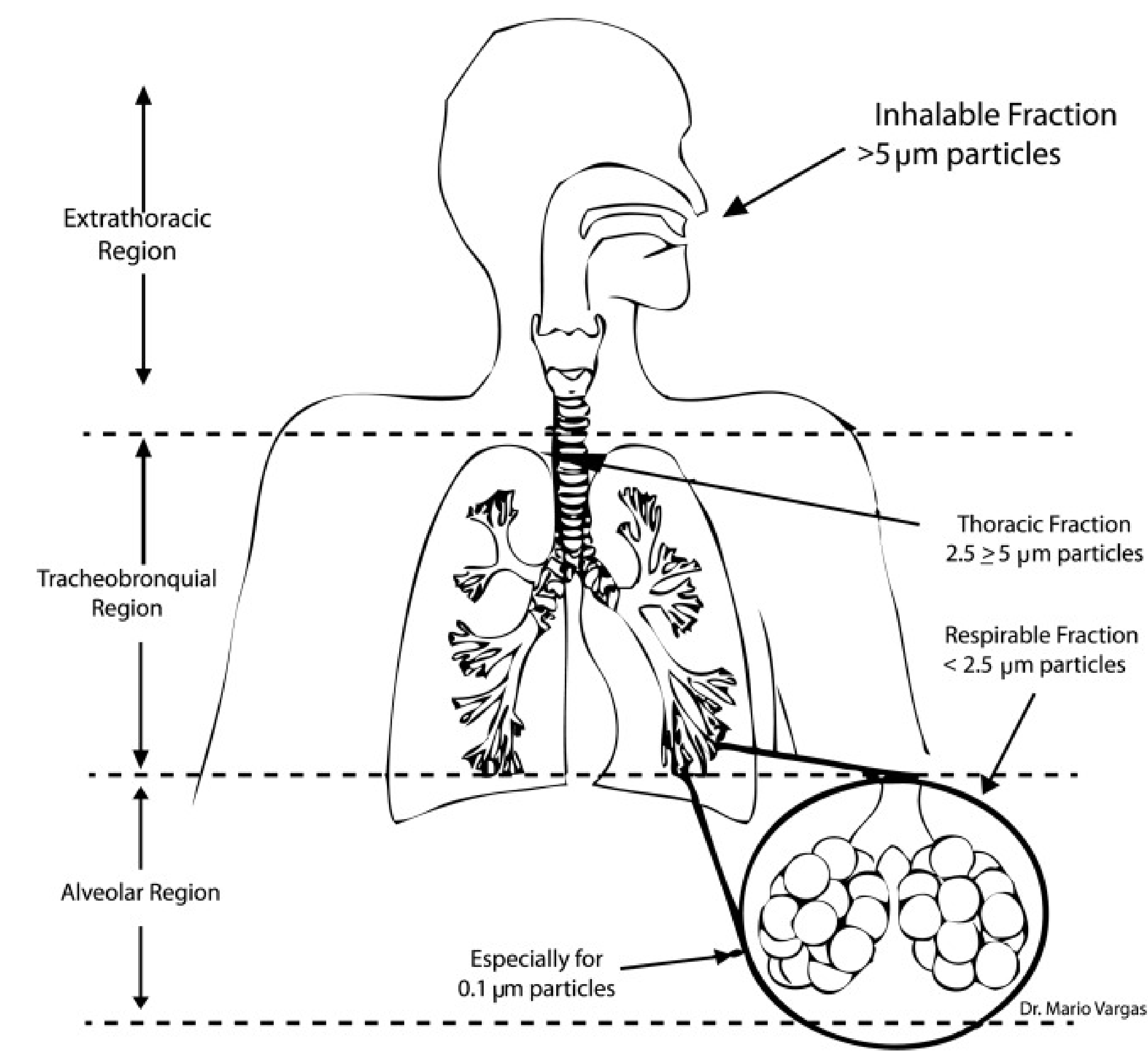


Figure 5: Regional Deposition of Dust Particles

How far the particle gets in the air passages of the respiratory system, and what it does when it is deposited, depends on the size, shape, and density of the particulate material. It also depends on the chemical and toxic properties of the material. Smaller particles with an aerodynamic diameter of about 0.003 to 5 μm are deposited in the tracheobronchial and alveolar regions.

The amount of dust and the kinds of particles involved influence how serious the lung injury will be. For example, after the macrophages swallow silica particles, they die and give off toxic substances. These substances cause fibrous or scar tissue to form. This tissue is the body's normal way of repairing itself. However, in the case of crystalline silica so much fibrous tissue and scarring form that lung function can be impaired.

Brick making process:

1. Preparation of mud

In this step the soil is excavated in steps and then laid on leveled ground. Then the soil is cleaned of impurities such as vegetation matter, stones or pebbles etc. After removing impurities it is exposed to weather for few months. This is called the process of weathering. After completion of weathering process the soil is blended with other material to prepare good brick earth. Then the mixed soil is tempered by being thoroughly broken up, watered and kneaded. The tempering is usually done in pug mill.

2. Moulding

Hand moulding: A wooden rectangular mould made in the shape of a brick is normally used for this purpose. 99% of the bricks are made like this.

The workers sit in squatting position while making these bricks and about 8kg's of weight is turned because of the clay being moist. This activity is carried on for 10 hours daily and leads to many muscular and skeletal problems very early in their lives.

3. Drying of Bricks

The moist bricks are kept at the beginning of the kiln ring and cool air passes through to dry them to prevent cracking during firing. They are arranged in a manner that when coal is felled from top to fire them, Parallel thin rows of brick wall.

The Workers who arrange these bricks are very skilled at only doing this job and it is also considered physical very strenuous.

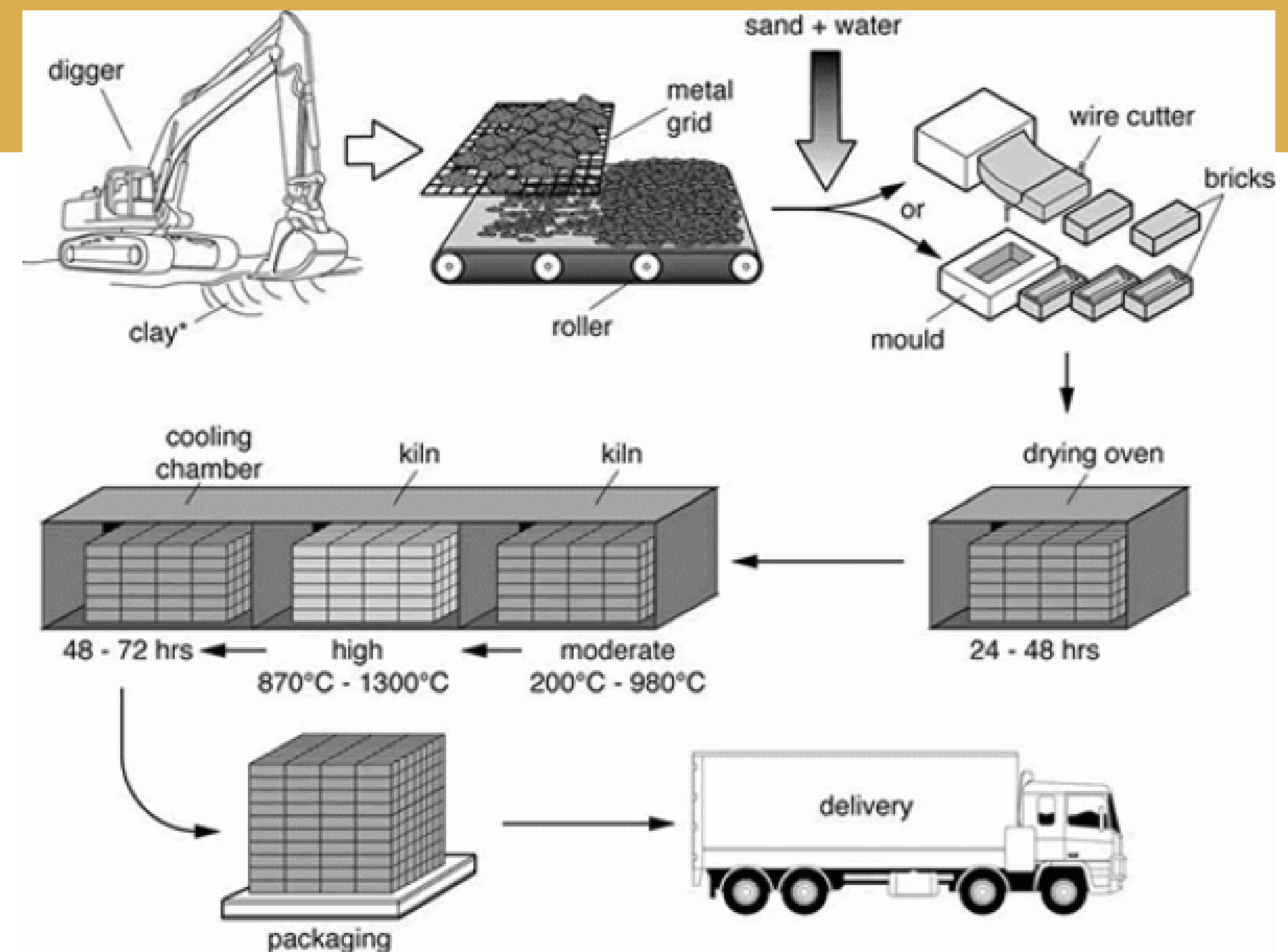


Figure 6:

4. Firing of Bricks

There are intermittent and continuous kilns. Moulded clay is stacked in the chambers with sufficient gaps between the stacked rows so that when coal is felled from the top, it reaches all corners and bakes them evenly. They are burned to high temperature slowly and cooled. One cycle of loading, drying, burning, cooling and emptying may take as much as two weeks. These processes are carried out intermittently in intermittent kilns and in cyclic order in continuous kilns. This is common for FCBTK, Zig-Zag as well as MCBTK.

After this stage the bricks are cooled and the Nikashi's take the bricks out where a shower of dust covers their entire body. They work in such situations for hours continuously.

Dust mask standards in market

3M respiratory masks

Respirator Rating Number Class

- 95 - Removes 95% of all particles that are at least 0.3 microns in diameter
- 99 - Removes 99% of particles that are at least 0.3 microns in diameter
- 100 - Removes 99.97% of all particles that are 0.3 microns in diameter or larger. HE or HEPA quality filter.

The most efficient and low cost filter fabric which is available in the Indian market is the 3M Particulate Respirator 9004 GV which has a N90 filter.

After a visit to the Venus, Safety and Health stall in the Disaster Management Symposium in IIT Bombay held from 29th Jan to 1st February, 2019, Samples of basic PM 2.5 masks were collected and their comfort and usability was understood. It has a provision of a special Butterfly exhalation valve which prevents excess humidity inside the mask and provides more comfort. It's reusable, washable feature was the USP.



Figure 7: 3M Particulate Respirator 9004 GV



Figure 8: Qmask dust and pollen



Figure 9: Venus Dust respirator, V-425, SLOV-V

What is Particulate Matter?

It is a mixture of solid and liquid particles suspended in the air which could be hazardous and their source can be inorganic or organic or both. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eyes and can be trapped using regular dust masks or scarfs tied securely on the face. Others are so small they can only be detected using an electron microscope.

Particle pollution includes:

- PM₁₀ : inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- PM_{2.5} : fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

Sources of PM

These particles come in many sizes and shapes and can be made up of hundreds of different chemicals. Construction sites, unpaved roads, fields, smokestacks or fires are the major sources of these particles.

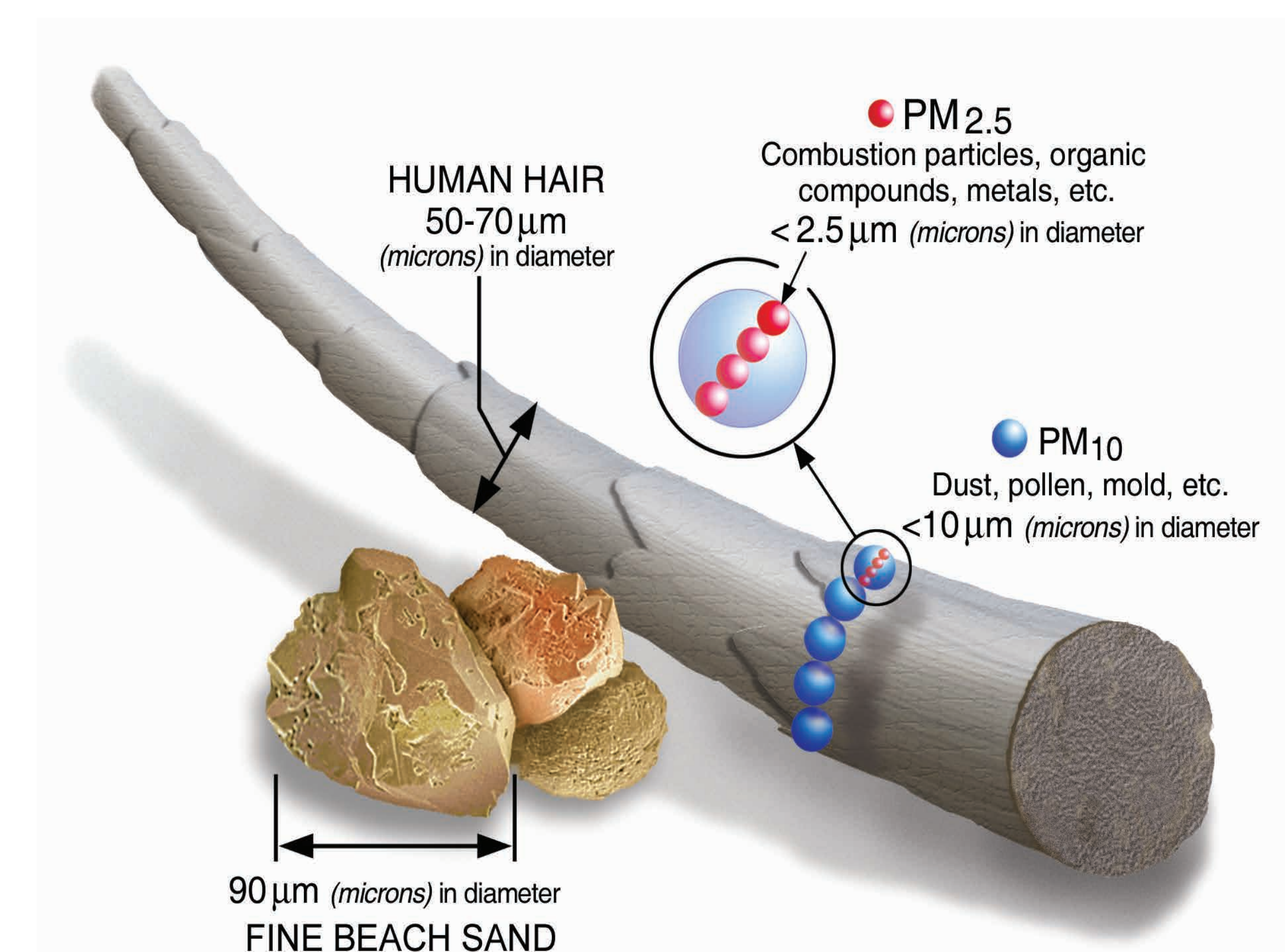


Figure 10: Particulate matter size comparison and visualization.

Design Specifications

Design Brief:

To design a low cost and ergonomic dust mask for brick kiln workers in india.

Functional Requirements:

- Socially acceptable by the workers and their family.
- Low cost for the workers.
- Comfortable to wear in hot temperatures for minimum 5 hours
- Does not cause fogging.
- Easy for the worker to put the mask on their own.
- Reusable: Easy to clean everyday.
- Has a long life of atleast one month.

User Group details:

- Age group: 4-44 years
- They belong to very low income group and from the schedule class category.
- Work for about 14 hours a day with very low wages

What is the need?

Some brick kiln workers put their spare dupatta to cover their head and face in different manners but majority do not cover their air passages at all. Workers who transfer baked bricks away from the kiln face the highest amount of dust exposure. There is a need to sensitize them to protect themselves and prevent respiratory diseases. Conventional masks available in the markets have high grade of filter in their fabric but are not viable for purchase by the workers. There is also an issue of it not being socially acceptable by the families as seen by the previous research done in Udaipur. This was observed when the female worker used the sample mask provided. Therefore there is a need for a design intervention where the workers can get dust protection in a low cost, socially acceptable and comfortable manner.

Current protective clothing



Figure 11: Women workers in Punjab



Figure 12: In cities



Figure 13: Aqua: Tube Face Masks

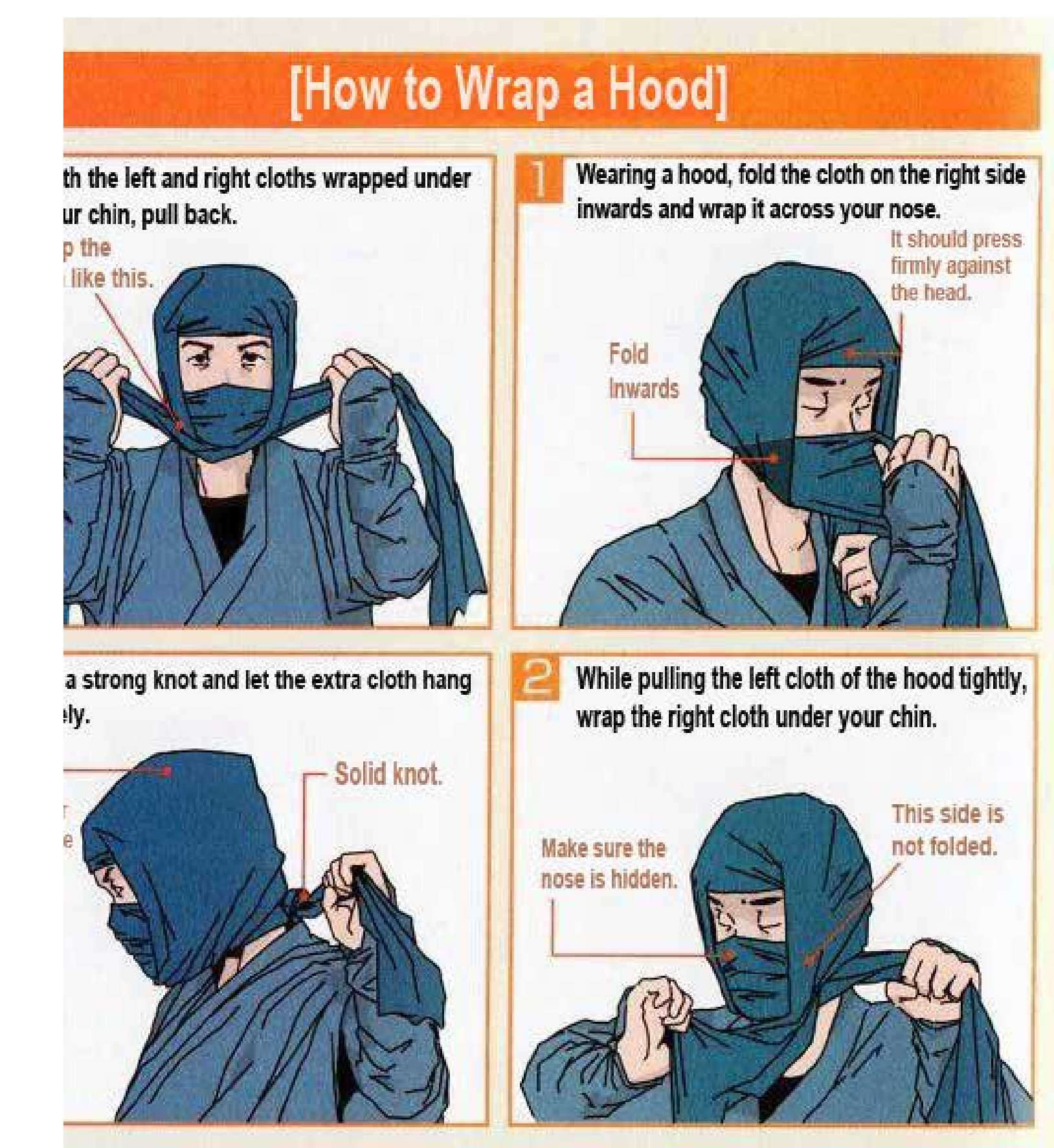


Figure 14: Ninja Hood



Figure 15: Tying steps by women in cities

Concepts: Scarf tying explorations



Figure 16: Less secure but more breathable



Figure 17: 3 step tie (More secure)

Results from previous research done by Ms. Pooja kulkarni:
It was concluded that polyester is less breathable than cotton but having multiple layer may improve the dust capturing performance.

The following table shows the largest particle size that passes through the filter.

Sample Number	Type	Particle size			
		1	2	3	
1	White silk	318 μm	343 μm	235 μm	BEST
2	Red polyester	129 μm	104 μm	164 μm	
3	Maroon georgette	256 μm	301 μm	359 μm	WORST
4	Blue cotton	360 μm	382 μm	473 μm	

Figure 18: Concluded results from the research

Different tying styles for cotton and polyester were explored which have difference in the number of steps to tie them. A basic filter mask is worn underneath. The extent of security and comfort were also the basis of selection.

- How is it fixed?
- Clothespin.
 - Safety pin.
 - Button and Elastic band.
 - Simple thread of 7 mm diameter.

Concepts: Masks with fabrics

The following ideations have been done keeping in mind the fabric used will have the inner most layer as cotton which will be touching the skin, the middle layer will have filter fabric and the outer will be polyester fabric since it captures the most amount of dust. There are other items needed - thread & needle, Fabric Elastic strings, Scissors.

These can be worn underneath the dupatta/scarf for overall better protection or without it.

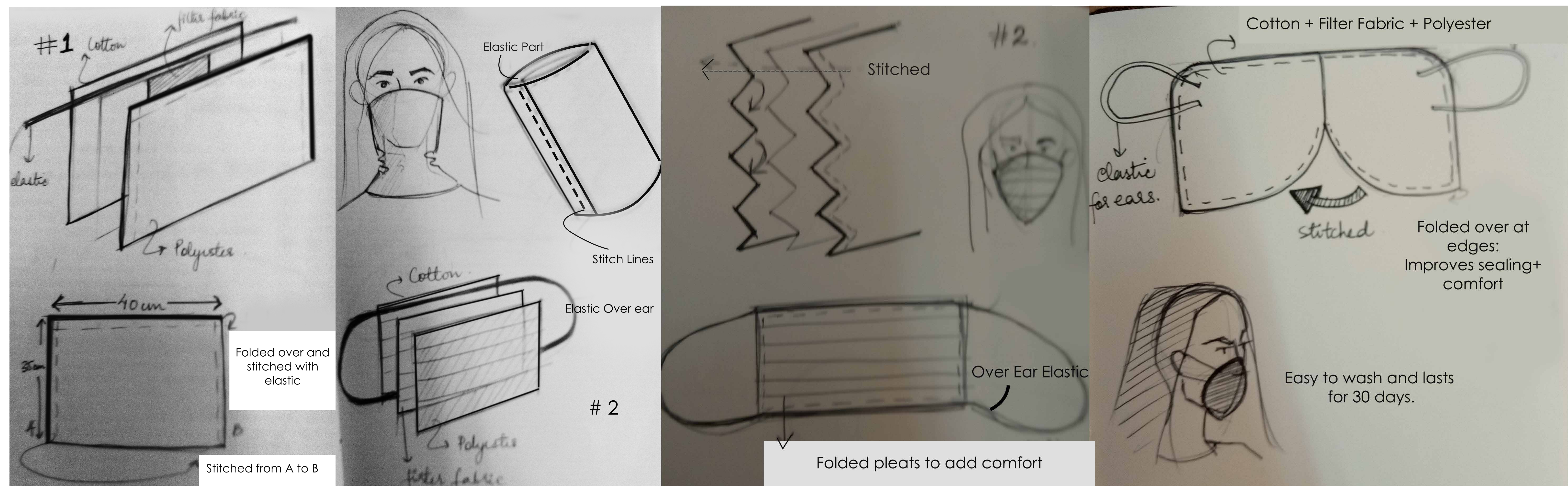


Figure 18: Concepts

Summary and Conclusion

Trying to introduce dust masks in the brick workers life which blends in with their own attire and does not look alien or scary to them can help overcome the problem of them rejecting the market masks which was observed in the last study¹⁷. Concepts were generated for the same using the ideal combination of multiple fabric mask. The bottom most layer being cotton (most breathable in such high temperatures), the middle one being filter fabric by 3M, N90 grade and the outer most layer being Polyester which has the highest efficiency of particle capture¹⁷. Simple cutout shapes and stitches along with elastic were one set. The other set of concepts where the user ties cotton fabric around the head while wearing the filter fabric mask inside. These need to be tested out for dust analysis efficacy.



Figure 19: The Nikashi's at work

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Image References

Figure 1:

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Figure 2:

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Figure 7:

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Figure 6:

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Figure 18:

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