CHAPTER 2

REVIEW OF LITERATURE

The second chapter of the present study is on the "Review of Literature". It is divided into three sections namely, theoretical review, technical review and research review. This chapter begins with an overview of how this chapter has been organized, followed by literature reviews. This chapter focuses on what has been done so far and how it is related to the present study being conducted. This chapter has an inventory of the review of literature pertaining to the shawls' history in India and its preservation and conservation practices in museums and private organizations. The research has been formulated with the key endeavour to conserve these precious momentoes for future generations to come and to implement its conservation methods. Fundamental information about fibers and structures that affect the long-term stability of textiles have been provided in the theoretical review. Both internal and external agents of deterioration have been described in the technical review. A wide range of preventive conservation strategies specifically related to shawls has been explored. Basic conservation interventions have been presented, demonstrated and issues in ethical decision making have been addressed in this chapter.

These have been covered under the following heads:

2.1 Theoretical Review

2.1.1 Historical background about shawls

2.1.2 Fundamental information about woollen fibers

2.1.3 Agents of deterioration and its preventive conservation

2.1.4 Remedial conservation processes

2.2 Research Review

2.1.1 Historical background about shawls

The review of literature is an important step in understanding the researches in India. It helped the researcher in framing and defining the problem, objectives, research design and methodology of the research. The interpretation of results was also done in view of the research works already done. The historical background was mainly necessary to know the shawls from the earliest recorded times that mythologies and religions have presented to us along with 'prehistories', as the man always seeks out his links with the past.

The shawl is one of India's best woollen products. It is unique, while it offers the intimacy of a warm garment. *Shal* more commonly known as shawl is a length of intricately woven or embroidered material used as a wrap around the body. It was colloquially called Jamawar because the kings and courtiers used to buy it by the yard, 'war', and make it into a 'Jama', a gown or robe" (Sethna, 1973). Indian shawl was usually $2^{1/2}$ yards, long and $1^{1/4}$ yards, wide. For added warmth, a doshala double this size was used (Saraf, 1985). The word 'shawl' itself was eastern in origin, being derived from the Persian shawl, which was originally signified as only a length of fine woollen cloth rather than a garment. Shal could be referred to a scarf, a mantle or a turban, among other things.

The term shawl, has been used to describe a type of woven textile, was the generic term for a length of cloth draped over the head and around the shoulders and worn by both men and women. Shawls made of cotton, silk or wool were seen in great variety in South Asia. There may be unadorned lengths of course, often domestically of woven cloth, striped, plaid or with contrasting borders (Askari, 1999).

From the literary evidence, it was known that spinning was exclusively the occupation of the women. For weaving, first the certain number of threads have to be stretched parallel to each other, i.e. a warp has to be prepared. This activity in the Vedic language was known by the verbal root *tan,* the warp was called *tata* or *tanto* and the warp threads *tantavah*. Wool was called *oornaa* (h) and *stuka*. According to K.F. Geldner, the latter term was described as the "sleek-haired sheep which is suitable for the production of wool", and according to H. Oldenburg, "carded wool". Wilhelm Rau in his article in the book named "Handwoven Fabrics of India" wrote wool was also an item for bartering in a raw condition as well as in the form of spun yarn (Dhamija and Jain, 1989). Wool is the fiber of a living animal. It forms the protective covering of the sheep, insulating it against both heat and cold, thereby keeping its body temperature even. The majority of amino acids in the protein of the wool are keratin which contains insect attracting sulphur. Wool weakens considerably when wet. Wool fibers absorb more moisture and accept dyes better as compared to the cotton fibers. Chattopadhyay (1985) stated that wool seems to have been directly created by Brahma like the kusa grass used in worship. In woollen materials, the most coveted is pashmina, made out of the wool from the underbelly of the Himalayan Pashmina goat when it lives 14,000 ft. or above the sea level. The finest was obtained after very selective sorting. The finest was shahtoosh which could be drawn through a ring and was, therefore, called a ring shawl, and through extraordinary light, it was amazingly warm. According to the Dhamija and Jain (1989), it was however certain that the sheep wool was used for spinning and therefore, the sheep was called urnavati and the wool avika. The Brihadaranyaka Upanishad mentioned pindvavika which was made from the sheep's wool and was possibly a woollen *chaddar* or a shawl.

Four categories of shawls

The shawls have been divided into four categories - *Khachita, vanchitra, khandasamghatya* and *tantuvichchhinna*. The commentary described *Khachita* as suchivanakarmanishpaditam which may either mean "made by weaving and embroidering" or "made by twill- tapestry process". If this explanation is correct then it indicated that even in those ancient days the tilikar process of Kashmir in which the patterns were woven on the loom and amlikar process in which the patterns were embroidered existed. In Khachita shawls apparently, both processes were employed. The commentary described *Varna Chitra* as vanakarmana kritavaichitryam. Apparently, in this process as in the modern tilikar process, the designs were woven on the loom. The *khandasamghatya* in the commentary is described as khachitanam utanam vabahunam khadanam samghatenanispaditam, i.e. the shawl made by joining many Khachita or woven pieces. It was apparently a form of Kashmir shawl in which patterns were woven on many stripes measuring from twelve to eighteen inches; these are either joined to obtain a complete pattern or simply attached to a shawl. These strips were at times embroidered. The *Tantuvichchhinna* is described by the commentator as anutavisrishtaih tantubhih madhya-kritavichchedyam jalakopayagi cha, i.e. obtaining patterns in the middle by unwoven yarn or a trellis pattern. It is possible that the netted border of a shawl made by tying the unwoven ends was meant here (Dhamija and Jain, 1989).

From the above account on shawls, many points were clear. Firstly, the Tus shawl was made from the hair of the Tus goat. In the 19th century when Moor craft visited Kashmir there were two kinds of goat-wool: pashm shawl obtained from the wool of domestic goats and Asli tus obtained from the hair of wild goats and sheep. It was chiefly black, white or reddish. Secondly, the corded and patterned shawls (Tarah shawls) were made of either white, black or mixed wool. The white kind was formerly dyed in three or four colours but in Akbar's time, the number of colours increased. Thirdly, attention was paid to the manufacture of the following varieties of shawls:

1. Zardozi- Apparently this shawl was embroidered with gold wire and sequins.
2. Kalabatun- The design seems to have been brocaded with gold wire.
3. Qasida- In this variety the pattern was embroidered and not woven.
4. Qinghai- This type was made either of silk or gold wire and bore pine cone patterns (qalghi).
5. Bandh nun shawls had a tie-dye pattern.
6. Chintz shawls were apparently painted or decorated with floral patterns in the manner of calico prints. According to Moorcroft even in the early 19th century some shawls with green flowers tied in small hard knots to protect them from the action of the dye were made. When united, each flower was surrounded by a small white flower to which small eyes or spots of yellow and red were added by the embroideries.
7. Alchah was a white banded stuff.
8. Purzdar is described according to the Prince of Wales Museum manuscript, it was known in Turkish as Karh and in Hindi as rusa. Purzdar was either a big piece made of various stripes joined together or had a marbled (Arbi) design, or was given its name due to its good quality. (24)

Shawls in different regions of India

1. Himachal Pradesh

Chattopadhyay (1985) stated that the Himalayan region which is the real home for woollen and embroideries was the great shawl producing area, especially Mandi, Kullu, Kangra, Bilaspur, and Chamba in Himachal Pradesh. Here shawls were mostly woven in an angular geometrical type of motifs grouped in straight horizontal lines, bands, and stripes, one or two placed vertically. The outstanding feature of Himachal Pradesh shawls was their colourful intricate designs in tapestry technique and extra weft technique in twill weave (Bansal, 1994). Saraf (1985) said that most notable of these shawls was a soft pashmina, though nowadays most shawls are made of the woollen yarn called raffle. They may be either plain or patterned; for the latter, the skilled Himachal weaver finds inspiration in his beautiful environment and in the auspicious symbols of the hill people.

Traditionally Kullu shawls had three borders at the end (Bansal and Phadke, 1997). In the beginning, local wool was used as the raw material for making Kullu shawls. This wool is acquired from sheep (byangi, deshkad and imboo) bred in Himachal Pradesh.

The finest, the most sought-after variety of wool was known as byangi in the Pahari dialect and popularly known as pashm. Slightly inferior in quality but very soft to the touch was imboo, lambs' wool. The third variety, desar, was the most inferior and is obtained from the local breed of horizontal tailed sheep, gaddi or dumba. All over the state, throw shuttle pit looms had been used for centuries in the rural areas. The loom was stretched horizontally on the ground and supported generally by four to six posts, which was fixed deep in the ground in the rectangular form. A plain tabby weave was generally employed for the colourful patterns on the shawls, while the rest was woven in the twill weave. The former was the simplest form of weaving. The design was prepared by the interlacing of weft yarns with the warp yarns in a sequence of one down. The order is reversed for every subsequent weft thread (Sharma *et. al.*, 2008)

Traditionally, two varieties of shawls were spun here: the pattu for women including the chadru for men. Both were much larger than the shawls used by people in the plains. The chhanli was also a woollen shawl wrapped around the shoulders like a stole on fairs and festivals when the women join the men in community dancing. Invariably cream coloured, it had bands with colourful patterns (Aryan, 1993).

Bansal (1994) mentioned in the thesis that Kinnauri shawls were more intricate than Kullu shawls. These shawls were woven on narrow width pit looms in half width and later the two pieces were joined. The field was in 2/2 herringbone weave and design was in tapestry technique in 2/2 basket weave. Kinnauri designs and colours were based on

Buddhism and Tibetan culture. Motifs were angular and geometrical in shape and arranged in horizontal borders. In Kinnaur, they used 7 colours; red, blue, yellow, green, orange, white, black. In Kullu, vertical borders were woven separately and attached later. Other bright colours were also added later.

Designs and motifs on Kinnauri shawls were panma, topurut, tanka, gotopurut, gao, sanp or 's', chalo panma, mandal, changri, palpe, ratmi, chotren, thalo, adha, pat land, chakri, gyat patlang, changri, gurgur, khiran tumhi and yun rung.

Designs and motifs on Kullu shawls were gugtu, kira, aathh, numbro, bulbul chashm, char bulbul chasm, gulab, rani bel, kancho, dhoop chhaon, ganesh chidhiya, titli, ghanti, ambi, mergenda, phool, mandir, kanghi and tundu.

Dhamija (1970) also mentioned a kind of shawl which has the finest variety of all. This shawl however, was the aksi (reflection) in which the design was produced on one side by splitting the warp threads into a half and leaving the other side plain. The Himalayan zone produced other varieties of shawls and tweeds too, but the local people made them primarily for their own use. There were shawls woven from local wool carrying checks with cross borders woven in bold colours and using the motifs inspired by Buddhist traditions in Himachal. The chorten (commemorative building), vajra (thunderbolt), and swastika were the common motifs. These shawls had come to be known as Kullu shawls though they were woven all over the Himalayan belt.

2. Jammu and Kashmir

Kashmir is a land of majestic mountains and shimmering lakes. It has a unique history of weaving and embroidering the world's finest shawls. Kashmir's fame is in spinning, weaving, and patterning of beautiful pashmina. This was also known as cashmere from the old French spelling of Kashmir. The wool itself, came from the dry, high altitude plateaux of neighbouring Ladakh and Tibet, and also far away in Mongolia. (23)

The first substantial documentary evidence about shawl industry and the large collection owned by Emperor Akbar appeared in the literature of his reign (1556-1605 A.D.), though unfortunately with no description to suggest what these would have been. The earliest known shawl fragment was dated about 1680, and shawls were depicted in Indian miniature paintings from about the same time. These, however, appeared to have been hand woven with the intricate patterns executed in a twill tapestry technique of incredible fineness. This technique was known as Kani in Kashmir, the name of the little wooden bobbins which contains the weft patterning of yarns (Dhamija, 2004).

According to Irwin (1973) in "World cultures arts and crafts" in the 16th century, Kashmir has been described as an isolated mountain valley in the north-western Himalayas, famous for its delicate woollen shawls, when men in India and Persia wore folded over one shoulder or as a belt under European influence. The early types with their delicately coloured floral patterns on a monochrome ground developed into more and more sumptuous, by European Standards Oriental forms with the buta motif, still known as the Kashmir pattern today, were dominant among them.

According to Gupta (1978), there were varieties of shawls woven in Srinagar such as ring shawls, pashmina, shahtush, do-shala, do-rookha, kani, patoos, fur, lebnan, stretch, amli, raffal and aksi shawls (checkdar or striped). Pashmina and shahtush shawls are not produced now because the looms and weavers are not available as well as the raw material is also very expensive. Some of the embroidered shawls made in Kashmir were :

- Amli shawls
- Aksi or Aksnuma shawls
- Sangeen Buttidar shawls
- Arrikan or Zalakdozi shawls
- Purmattan shawls
- Jamawar shawls
- Palavdar or Dordar shawls
- Cheenar border shawls
- Soznikar or Vata-chikan shawls
- Kanikar or Tili shawls
- Poshkar shawl with floral motifs

The most important Kashmir shawls, definitely pre-Moghul in origin and design, were made in both wool and silk. They were woven in long strips on small looms, the coloured weft being introduced by means of floating bobbins known as tojlis. The design was produced by moving the threads of weft, back and forth throughout the warp. The narrow strips of cloth thus made were then carefully joined together with stitches that were almost invisible. These shawls were often embroidered and were known as Amlikar. The term Amlikar is a graphic description of the technique's intent. Aml in Persian literally meant 'action' but was also used figuratively by calligraphers and miniaturists while signing their work (e.g. the word, aml. followed by the artist's name), while kar means 'work' (Rehman and Jafri, 2006).

Most of the woollen fabrics of Kashmir were made of pashm, the wool of a certain Asian species of mountain goat, Capra Hircus, and hence were called pashminas. The fine fleece which grew beneath the rough outer hair, the finest being that from the under-belly, and sheds with the onset of summer was used for shawl weaving.

There were two kinds of shawls: One was known as twin-shawl or do-Shala (sewn back to back) and the other was chaddar-rumal or kasaba. The first one was always sold in pairs. The following terms were used to designate the different varieties;

- Khali-Matan: The central field was plain and unadorned.
- Char-baghan: made up of four colours joined together.
- Chand (moon): the central field was decorated with a medallion of flowers.
- Kunj: the central field was decorated with flowers in the centre.
- Palledar or Shahpasand ("king's choice") the end borders were broader than the side borders.
- Dorakha: the pattern was so woven that it appears the same on both sides. (53)

The colours commonly used were yellow (zard), white (safed), black (mushki), blue (ferozi), green (zingari), crimson (gulanar), purple (uda), and scarlet (kermizi) (Mehta 1960). The dyes also professed to give sixty-four shades, such as crimson (gulenar) obtained from cochineal, kermes, logwood for other reds and blue and green from Indigo, carthamus and saffron yielded various tints of orange, yellow, etc. (Dhamija and Jain, 1989).

The 'Jamawar Shawl' was a pure wool or cots wool a blend of cotton and wool used as background, on which a floral design and brocade were produced with silk and fine quality wool like Pashmina. There were shawls, square in shape called 'Kasaba', specially produced on the demand of Europeans.

The embroidery was comprised of the wide spectrum of colours of light and dark shades, such as crimson red, scarlet red, blue, yellow, green, purple, black and brown. Earlier, the yarns were locally dyed with indigenous natural colours (Naik, 1996). Kashmir shawls produced in wool, Pashmina wool and sometimes in blends of silk and wool, were world famous. Motifs were woven in extra weft and tapestry techniques. Famous motifs were paisley, lotus and foliage. (Bansal, 1994).

The technique of Kashida in Kashmir originated with darn stitch, used as a finish to the shawl by the Rafugar. It was a simple running stitch which gave a woven design effect on the shawls. Stem stitch usually in darker shade was used to give shape to the motif by outlining it. Other stitches included were sozni (satin), zalakdozi (chain), and vata-chikan (buttonhole). Occasionally herringbone, Doria (open work) and talaibar (gold work) were also employed (Naik, 1996).

The finest shahtoosh shawls with intricate embroidery as well as overall jamawar shawls on pashmina were made (Naik, 1996). The raw pashmina wool, sheared from the fleece of the domesticated Capra hircus goat comes from Tibet, Yarkand, Ladakh and for the last few years from isolated farms in Kashmir. The natural colours of Pashm were white, fawn or camel, as well as a dun colour similar to the natural toos shade. The second kind of mountain goat that supplied the Kashmir shawl industry with pashmina was the Capra ibex, also known as the Himalayan or Siberian ibex (Rehman and Jafri, 2006).

Mehta (1960) stated that before the actual weaving of the shawl, six specialists were concerned in the preliminary preparation: the warp-maker, warp-dresser, warp-threader, pattern-drawer, colour caller, and the pattern master. The warp-maker twisted the yarn into the thickness required for the warp, this being generally 2000-3000 double-threads; the warp dresser then starched the warp and the warp-threader passed the yarn through the heddles of the loom. The pattern-drawer or *naqqash* coloured his own designs, but usually, this was left to the colour caller known as the *tarah-guru*. With the drawing in black and white before him, the latter called out each colour, from the bottom upwards, and the number of warps along which the design is made. These instructions were noted down by the pattern-master, the *ta'lim* guru, and translated into a kind of shorthand that the weaver could understand and follow.

The peculiar feature of the famous Kashmir shawls of the 18th and 19th centuries is that the design, like a tapestry, was woven into the very fabric of the cloth. This was done by replacing the shuttle used in ordinary weaving with a series of small, eyeless wooden bobbins known in Kashmir as Kani, each filled with coloured yarn (Jaitley, 1990). By 1836, pines of all sizes had encroached on the field of Kashmirian shawls. Ornamentation grew even more profuse and the shawls became increasingly heavy to wear. Von Hugel described a workshop in Kashmir. "Twenty-four weavers worked at eleven looms in the following way: 2 looms with 3 weavers each for the large pines, 4 looms with 2 weavers each for the small pines, 1 loom with 2 weavers for the field and 4 looms with 2 adolescent weavers each for the borders. (49)

In the book named " Handbook of Manufacture and Arts of Punjab ", B.H. Baden Powell (1872) described the terms by which the different types of ornamentation of the embroidered shawls were known. The *Hashiya* was the border running along the whole length and it could be single, double, or triple. The whole of the embroidery at the two ends of the shawl was the phala, with the tanjir or chain running above and below the principal area of the phala. The ornament situated on the inside of the hashiya and zangir enveloping the whole of the shawl was the daur or dhour. The corner ornament, mostly consisting of a cluster of flowers, was called the Kunjbuta. The mattan was that part of the ground that was embroidered. The cone or buta motif with its flowing curves and minute diaper of flowers was the most popular. Generally, there was only one row of the cones; but when there were two, the buta was known as dokhad, sekhad, up to five rows, and tukadar if the rows were above five. The jhal was the decoration that sometimes filled the ground between the cones (Mehta, 1960).

3. Gujarat

Gujarat produces woollen shawls in tie-dye technique. Sheep and camel wool was spun into yarn and woven on the loom to make shawls. The shawls were coarse, thick and large. To soften them, they were dyed in natural colours with tie-dye technique. The weaving patterns on both sides of shawls were intricate with extra weft. Motifs were derived from the environment, like a camel, cactus plant, temple structure, and date plant. The shawls were woven on pit looms in small width. They were made in pairs and stitched together with a fishbone stitch. Cotton warp and woollen weft began to be used in place of wool and border patterns created with thick cotton dyed yarn (Hatanaka, 1996).

In Kathiawar, Kutch, as well as in Sind (now in Pakistan), both the darning and the chain stitches were used with exceptional skill. The embroidery of Kathiawar, Kutch, and Sind was very similar and this was not surprising considering their geographical affinity. The distinctive embroidery of Kutch was known as the Kanbi after the Kanbis (farm cultivators) and Ahirs (cowherds) who generally did it. The embroidery of Sind manifested many forms due to multiple influences- the darning stitch of the phulkari of Punjab, the chain and interlaced stitches of Kutch, and even the use of tiny mirrors within the designs. The designs were simple and colours were more subdued in comparison to those of lower Sind where the influence of Kathiawar and Kutch seemed to have been greater (Pal, 1978). The Kutch embroidery was very fine and had a special delicacy. A hook-like crochet needle was used to speed the work, which was introduced from beneath the cloth. Sometimes mirror pieces or jewels were also sewn in (Chattopadhyay, 1985). One of the examples of Kutch embroidery is Dhebaria Rabari Shawl, Kutch. The wool thread in the shawl was spun by the women themselves with wool sheared from their own sheep. The extra weft patterns on the end borders were woven with cotton threads. The shawl was then tied into different patterns and given to the dyers to dye. The wool was dyed in deep colours, but the cotton thread did not absorb the dye, leaving the woven pattern white and in strong contrast to the background colour. The shawl was woven on a narrow width loom in two pieces and put together by the women; even the joint was embroidered with multi-coloured threads (Dhamija, 1985). The work of the Rabaris was quite impressive, done against a dark Khadi background, usually deep maroon with any subtle shade that would show off the needle-work to advantage (Chatopadhyay, 1977).

Gujarat also produced the shawls in cotton, wool and their union fabrics with designs in extra weft technique. "Tangalias" woollen shawls of Gujarat were woven in half width and two pieces were joined together in the centre. The pattern was usually woven on the vertical half of the shawl by wrapping yarn around a group of warp yarns, making sort of a bead called dana. Traditionally, a Tangalia shawl was made of local wool and cotton yarn, 10 x 4 feet in dimension. It was worn for the special occasion by the shepherd women of the Saurashtra region. The basic fabric was wool, on which the bead-like dana work was done with cotton fibers to create the motifs. A dana is formed on the weft yarn, by tying together at least three warps with a fine thread around them. The art of Tangalia weaving is centred at Surendra nagar and Chotila. The weavers in this region make black and off-white coloured shawls in thick coarse wool, for the Rabari and Ahir communities. The characteristic feature of this textile is the beaded look on the surface. The abundantly available sheep wool was spun and plied into weaving yarn for the warp and weft. Elaborate designs were also done for marriage shawls. Tangalia textiles were mostly black, deep maroon and off-white in colour (Hatanaka, 1996).

4. Nagaland

Nagaland produced woollen shawls which has red and black vertical bands. Bansal (1994) specified a distinct warrior shawl of Nagaland, known as the Tusung Kotepsu shawl, which had in the midst a white panel encircled by red and black stripes and checks. The white panel carried drawings made in indigenous, indelible black ink of mithunas, cocks, human heads, speaks, daos, the sun and the moon. This shawl could be worn only by the warrior who has been victorious in battle who has taken a head. There was another shawl which could be worn only by a rich man, whose family has celebrated the mithun sacrifice feast for three generations.

Another special shawl worn by the warriors during war times was also embroidered by the women at home, known as 'Zamphie'. Only the people, honoured by the king were permitted to wear this special shawl.

Popularly known as Sami Lami phee, the Angami Naga shawls were gifted to the valiant fighters by the rulers of Nagaland in recognition of their service during the ancient times. The Angami Naga shawls were usually embellished with uncommon design models of several wild animals toward the black base of the shawls. The textile consisted of locally spun thread and natural colouring. The loom, which every house possessed, was a simple tension loom. The best Naga shawls having different textures were woven of yarn. The shawls on the entire length or borders were striped, each tribe having their own mode of geometrical designs as part of their embroidery. Stripes in all cases were coloured differently from the main background of the cloth. In respect of spinning, the Nagas used the spindle for spinning cotton while the Semas and Aos had a spindle raised with a flat stone where cotton, jute and even mottle-fibers were woven into cloths. Angami loom was a simple loin loom for the Ao, lothas and sema type although petty variations were noted as regards the Angami way of warping and the setting of the loom (Devi, 2010).

Ao rich man shawl, Ao warrior shawl (TsingKotepsu), Angami shawl (Lohe), Zeliang shawl, Sema shawls, Yimchunger shawl, Chang shawl (Tobu nei), Phom warrior shawls, Rengma warrior shawl (Teri Phiketsu), Konyak and Khieningan shawls are some of the Naga shawls.

The Nagas used dark blue, red and rarely yellow dye. The blue colour was collected from the leaves of the Strobilanthes flaccidifolius, the Aos plant. One of the characteristic highlights of Naga shawl was that three parts were woven individually and sewed together. In fact, the central strip was more decorated than the two others which generally had more or less the same pattern.

The chuchusubangsu shawl could be worn by men of Mulir clan. Another shawl worn on festive occasions by men of wealth or the sons and daughters of wealthy men was Aomelep su, in which dog's hair dyed red was woven at regular intervals so as to make the shawl appear shaggy in spots. Rongsu shawl was also one of the most decorative Ao cloths.

Other shawls consisted of Tiong Kong su having each side of the centre, a red band with black streaks but the central narrow breadth was woven of dog's hair dyed red and uncoloured thread; Tabensa su shawl had red and black strips and black as the predominant colour. Lungkhum Subang was a shawl with a red edge on two sides, a white stripe in the centre, but its main part was black. Another kind of cheap shawl used by men and women for rough wear was a black shawl called Ratapfe of 1.6 meters long and a little less than a meter in breadth.

Yimchunger Naga tribe had more than 12 kinds of cloths. One of the most ordinary clothes used by both male and female without any restriction was a black shawl called Aneak Khim. The next type of shawl commonly worn by male and female alike was Mokhok khim. The Amurk Khim was another kind of shawl which could be worn by both man and woman. Rong khim, one of the most attractive Yimchunger shawls could be worn only by a man who has taken heads in a war. Amerthre khim was another attractive Yimchunger shawl which could be worn only by a man, who had killed a tiger. Rehuke Khim or cowrie shawl was the most important cloth meant for the rich man of the Yimchunger tribe. On a black background, circles of cowrie were stitched in a pattern similar to that of the red rectangular design of Rong khim shawl.

Another Chang cloth, worn by the newly married couple was known as Silang nei. It was a blue shawl with no ornamentation of any kind. One of the most beautiful Chang shawls was called Tobu nei.

A man who has taken a human head in war or has offered the feast of merit as recognition of his wealth in his village may wear a cowrie shawl called by the Phom Fanet. Another handsome cloth, which the phoms called Henyu was a red shawl with narrow white horizontal bands at regular intervals of 6cm. The general pattern of Phom shawl was red with a broad median white band nearly 9 cm wide elaborately embroidered with red lozenges.

Sangtam shawl called Supong su was supposed to be used only by rich men. The ordinary shawl of the lotha was known as Sutam, a white cloth with broad dark blue horizontal stripes, which was worn by boys and men who have performed no social 'gennas'. The phangrhup shawl, was a dark blue cloth, edged with broad bands of red with a broad stripe running across the middle of the cloth parallel with the red stripes.

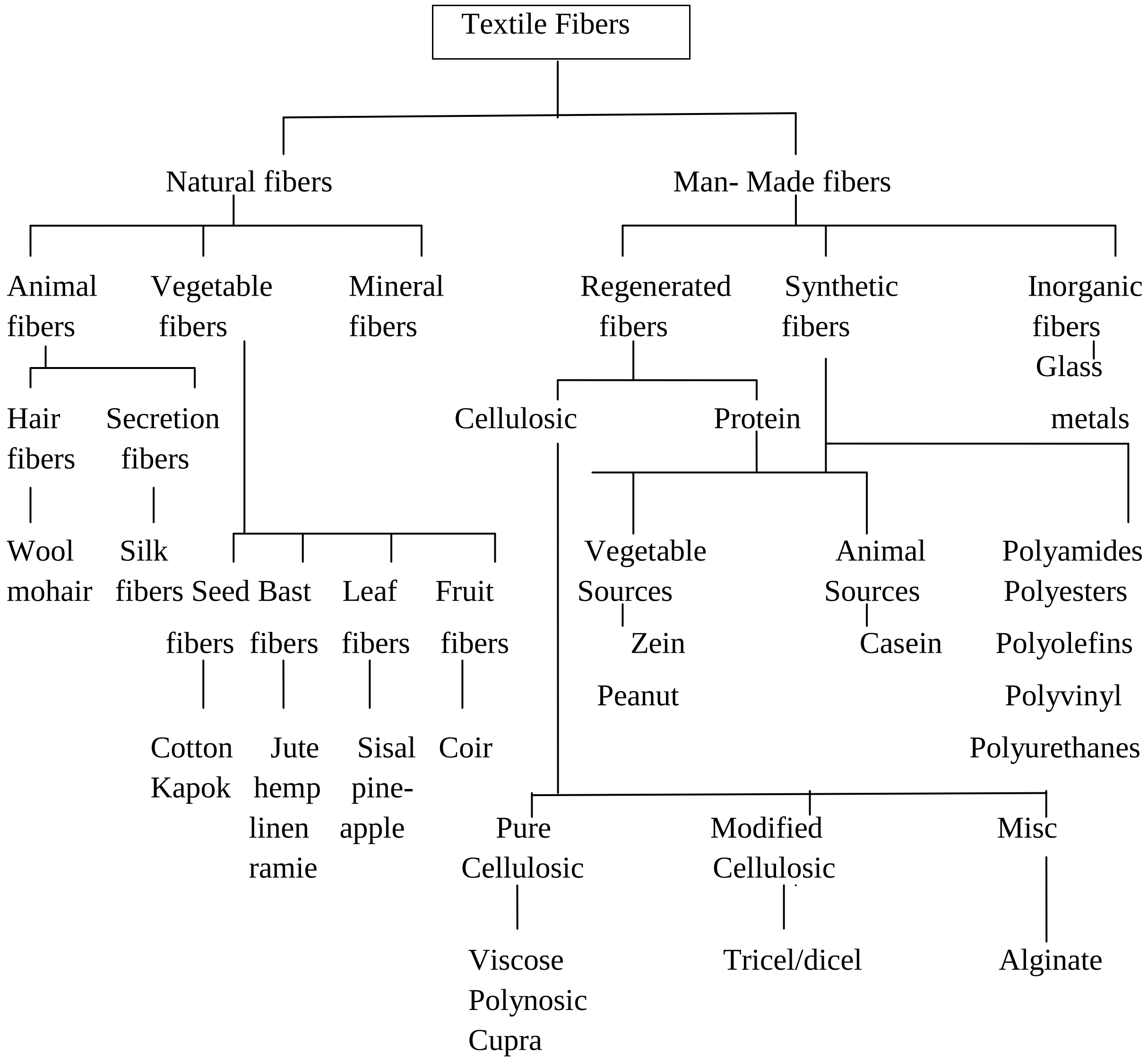
The most characteristic shawls of Konyak and the neighbouring tribes generally had an essential design of stripes and bands of contrasting black, blue, red and white. A remarkable shawl worn by the village elders in important meetings and conferences is called nye-myon. Another white shawl worn by women is called Nikola. A colourful and handsome shawl called Shatni may be worn by rich Konyak women. An aristocratic shawl generally used by the Konyak chiefs (Ang) and elders of the villages were called Meyni. It was a combination of broad black and red bands alternately (The arts of crafts of Nagaland, 1970). The lotha Naga shawl was woven in nine parts and stitched to make up a piece. The Lushai shawl or the complex Apatani priest's shawl was also pieced together (Dhamija and Jain, 1989).

2.1.2 Fundamental information about woollen fibers.

The researcher reviewed the related literature on the fundamental information about woollen fibers in view of the present study. It was important to throw some light on the fibres out of which the shawls are made. Protein fibres, like wool and silk, were more commonly found in the older shawls. Their methods of construction were carding, combing, spinning and weaving. Constantly folding of any fibre will result in breakage as the shawls cannot support themselves; they are subjected to the abrasion, losses, fragility and ultimately decay. Some kinds of damages are not reversible and therefore, there is a need for conservation of an artefact. It should be understood that before carrying out any kind of remedial conservation on an artefact it is very important to know the fibre composition and its construction. Therefore, the researcher carried out the detailed study of the woollen fiber, its identification methods, the fibre structure, the dyeing process as well as the physical and chemical effects on wool which have been presented below.

2.1.2.a Types of textile fibers

Textile fibers may be classified based on the source of raw material and chemical characteristics (Mishra, 2000).



2.1.2.b Identification of fibers

Fibers may be classified on the basis of their chemical constitution. Natural fibers are of animal origin (wool, silk), or of vegetable origin (cotton, linen, hemp). Animal fibers contain keratin, a nitrogenous compound. When they burn, they contract and give smell of burnt feathers due to decomposition of the keratin. Vegetable fibers are composed of cellulose. They burn easily and give off a characteristic odour of burnt paper. Thus, it is possible by a burning test to make a broad distinction between animal and vegetable fibers, but for specific identification, individual fibers must be examined under a microscope at about 100/150 diameters magnification (Plenderleith, 1956).

According to Hollen and Saddler (1958) fibers can also be distinguished through visual inspection and solubility tests. The visual inspection takes into account the observation of fibers characteristics such as the length of the fibers, its lustre, body and texture whereas the solubility tests confirm identification of natural fibers. Silk and wool are soluble in sodium hypochlorite solution at $75^{o}F$ whereas cotton and flax are soluble in sulphuric acid at $75^{o}F$. Wool fibers are self-extinguishing, burn slowly, curl, smell of burning hair and residue is like a bead. Wool is also resistant to acids at low temperature.

2.1.2.c The structure of wool fiber

All fibers, whether natural or manmade are chemically termed as polymers. Polymers are the long chain molecules or macromolecules that are required to form fibers. The process by which monomers combine to form polymer is known as polymerization.

Wool is the hair on the body of selected animals, such as sheep, angora goat, cashmere goat, camel, llama, alpaca, and vicuna. Scientists believed that wool was in use from 6000 B.C. to 4000 B.C. Ancient shepherds in the first century A.D. discovered that merino sheep could be bred to obtain good quality wool. In India wild sheep were found on the plains of Ganga-Yamuna even before one million years ago. Fossils of sheep were found in the ruins of Mohenjodaro. Sheep are found nearly in all states of India. Jammu-Kashmir, Rajasthan, and Gujarat produce more wool than Bihar, Andhra Pradesh, Himachal Pradesh and Maharashtra. Wool is the natural protein, multicellular and staple fiber. Its fibers density is $1.31 g/cm^3$. The wool fibers have a very good resilience property mainly due to its elastic nature and crimpiness. These crimps cause ends of the fibers to have a prickling sensation on the skin due to which the warmth is felt.

The wool is a linear, keratin polymer and has a helical configuration. The repeating unit is the amino acid which is linked together by the peptide bond (CO-NH-). The fiber generally known as fleece grows as the natural coat of sheep. The fleece is sheared with mechanical or power operated clippers known as raw wool. Raw wool contains impurities such as sand, dirt, grease, and perspiration which needs to be removed by scouring. A single fleece contains more than one grade of wool (based on fiber diameter and fiber length). The best quality of wool i.e. fine, long and soft fibers comes from shoulders and sides of the sheep. Short fibers are termed as noils and long fibers are termed as tops.

There are two qualities of wool, fine wool and coarse wool. The length of wool ranges from 36-35 cm and its diameter range from 10-70 microns. The colour of wool can be white to black/brown. Colour is due to cortical and medullar cells. Wool fiber has a highly complex structure. It consists of three main components:

Epicuticle: a thin layer of the waxy substance that is water repellent and protects the fiber.

Exocuticle: It is formed by the overlapping epithelial cells or wool fiber surface scales.

Endocuticle: It is an intermediate, cementing layer bonding the epithelial cells to the cortex of the wool fiber.

All protein fibers contain the elements carbon, hydrogen, oxygen, and nitrogen. Wool contains sulphur as well. Protein fibers except silk tend to be weaker than cellulosic fibers, and are weaker wet than dry. The specific gravity of protein fibers tends to be lower than that of cellulose. Wool fibers length varies with the breed of sheep (Hollen, 1958) .

2.1.2.d Dyeing of wool

The earliest fragments from Mohenjo-Daro (2500 B.C.) revealed a deep dark red fabric, the first evidence of manjita or madder used as a dye. As early as 1,000 years before Christ, Indigo for blue, madder and lac for red, myrobolam for ochre and the various substances for producing black were known. Added to this was green, procured by the use of pomegranate rinds mixed with indigo, iron shavings with vinegar for a deep rich black and turmeric for a strong but fugitive yellow (Rehman and Jafri, 2006).

According to Samanta and Konar (2011), "Natural dyes were known for their use in the colouring of food substrate, leather as well as natural protein fibers like wool, silk, and cotton. There is a rapid decline in natural dyeing due to the availability of synthetic dyes at an economical price and wide variety of colours. These dyes, however, produce skin allergy, toxic wastes and other harmfulness to a human body. Lately, a number of market dyers and textile exportation organizations have started looking at the potentialities of using natural dyes on routine basis dyeing and printing of textiles to succeed with environmental pollution caused by the synthetic dyes. Identification of dyes used in historic textiles through chromatographic and spectrophotometric methods as well as by sensitive colour reactions has been reported by Blanc *et al*. Szostek *et al*, studied the retention of carminic acid, indigotin, crocetin, gambogic acid, alizarin flavonoid, anthraquinone, and purpurin. Khan *et al*. studied natural dyes extracted from biomass products, namely cutch, ratanjot, and madder. The colour gamut of wool samples dyed with these dyes indicated red yellow zone. Maulik *et al*, also studied the extraction of hinjal and jujube bark having pH 4-5 for dyeing of wool and silk. The dye uptake appeared to be higher in case of wool than in the case of silk. Aqueous removal of saffron yields a yellow dye with medium wash fastness on wool and poor wash fastness on cotton. The wash fastness can be corrected by processing the metal salts before dying, as studied and reported by Tsatsaroni *et al*. A brick red shade dyeing for silk/wool using the isolated dye in presence of different mordant have also been achieved. Natural dye extracted from the leaves of the teak plant by using aqueous methanol produced brick red shade on silk and wool in the presence of different mordants. Chan *et al*. studied the dyeing of wool with four varieties of tea. Coloured protein fibers became blackish when ferrous sulphate was employed as a mordanting agent. Tsatsaroni *et al*. reported that the saffron yields a yellow shade on wool and cotton when mordanted with aluminium sulphate, iron sulphate, sodium potassium tartrate and zinc chloride.

2.1.2.e Physical and chemical effects on wool

There are few questions which come in the mind of any conservator before treating the woollen textiles. These questions are as follows along with their answers.

1. Why is wool a warm fiber?

The wool fiber is crimped, fine to thick and regular fiber. The crimped arrangement limits wool fibers from arranging themselves too firmly when being formed into the thread. As a result, it is possible to have woollen textile materials with air spaces occupying about 2/3rd of the volume. The warmth of wool fabrics is due to the more air spaces in the material than to the fibers.

2. Does wool absorb more moisture than cotton?

Yes, wool does absorb more moisture than cotton due to the polarity of the peptide groups, salt linkages and the amorphous nature of its polymer system which attracts more water molecules and enters the amorphous polymer of wool fibre (75-70%), whereas the cotton is a crystalline fibre (65-70%) and (30-35%) amorphous. Therefore, though cotton has countless polar-OH groups, these attract water molecules which can only enter the polymer system in its amorphous region, as the interpolymer spaces in the crystalline regions are too small for the water molecules to enter.

3. What will happen to the wool in humid conditions?

In humid conditions, wool absorb more moisture and three types of changes can occur in wool polymer due to humidity

- change in physical structure.
- change in physical properties.
- change due to chemical reaction.

Woollen textile materials distort more easily in damp and humid conditions because its polymers attract more water molecules. These water molecules tend to hydrolyse salt linkages and hydrogen bonds to allow some polymer slippage which becomes apparent as a distortion of woollen material.

4. What is the effect of light on wool?

When wool is exposed to light/sunlight it tends to fade or become dull coloured. The ultra-violet rays cause the peptide and disulphide bonds to severe damage. Fracture of these bonds results in polymer degradation. This degradation causes the wool fibers surface to absorb more light and to scatter the incident light to a greater extent. This results in yellowing and dulling.

5. Why are woollen textiles stored in dry storage conditions?

Woollen textiles are stored in dry storages in order to prevent the damage from the moisture and damp humid conditions.

6. What kind of bio-deterioration occurs on wool?

Woollen fabrics are readily eaten by larvae of cloth moths and carpet beetles. So mechanical properties will be changed, if wool is affected by moth, larvae and carpet beetle. Bacteria also grow over wool and they tend to break the scales if wool is placed in alkaline and hot condition.

7. What will happen if the woollen fabric is exposed to heat?

If the woollen fabric is exposed to heat, too much kinetic energy will generate. It will result in disulfide bond to rupture and this polymer fragmentation which will further result in surface discoloration of the wool fabric. Prolonged exposure to heat results in scorching. The brown to black discoloration of scorched wool occurs due to the formation of minute particles of carbon which are black in colour. Carbon is the ultimate degradation product from the wool polymers on exposure to the excessive amount of kinetic energy. Scorching accompanies weakening of the fiber.

8. Can bleaching be done over woollen artefacts? If yes, then how?

Yes, woollen artefacts can be bleached, an effective method of bleaching wool is to use a reducing bleach followed by an oxidizing bleach. Treat wool with reducing bleach such as acidified sodium sulphite, sodium bisulphite or sodium dithionite, which converts the discoloration on the fiber surface to colourless compounds. If an oxidizing bleach, such as hydrogen peroxide, is applied, then the colourless compounds are converted to water-soluble products. These can then be rinsed off the woollen fabric.

Exposure of bleached wool to atmospheric oxygen, moisture, and pollutants in the atmosphere tends to cause the wool to revert to its off-white colour and eventually to a yellow colour.

9. What should be done if wool gets affected by acidic conditions?

Acids hydrolyse the peptide groups. The polymer system of wool is weakened in acidic solutions. The fiber becomes vulnerable to further degradation because hydrogen bonds and salt linkages are hydrolysed to an extent. Therefore, it is always essential to neutralize the wool fabric after any acidic treatment.

10. Why is sulphur insect attracting?

Sulphur is a food for insects and they feed on it. Therefore, it is insect attracting.

11. What are the damaging effects of air pollution on wool?

Exposure of wool to atmospheric conditions causes weakening of the fibers by the excessive severing of peptide and disulphide bonds. It also causes the wool to get dull in its colour.

12. Why wool gives heat on wetting?

Wool gives the small steady amount of heat, whilst absorbing moisture. This is known as heat of wetting. It is due to the energy given off by the collision between the water molecules and the polar groups in the wool polymers. The force of the collision between the polar groups of wool and water molecules is severe enough to liberate energy which can be felt by the wearer as a slight warmth. As wool absorbs moisture, they have a much less chilling effect upon the skin in comparison with other textile materials under the similar conditions. The wool polymer system continues to give off heat until it becomes saturated with molecules.

13. Why will protein be more resistant to chemical attack?

When all the amino acids condense to form a polypeptide macromolecule, the chain forms a zig-zag arrangement due to the valency angle between the carbon atom and its two adjacent atoms i.e. carbon and nitrogen. Because of the spatial distribution of the groups around the carbon atom, R groups are placed in a different manner at different places. In case of straight chains of protein molecules simple and short side chains permit the formation of a fully extended chain. For e.g. polypeptide molecules having a higher amount of glycine will form a fully extended zig-zag chain. The protein molecules in this extended form have the property of adhering of adjacent chains. So, the molecules become incapable of developing the high degree of hydration. Also, the chain molecules cannot penetrate inside or in between chain molecules so easily. Due to this, protein will be more resistant to chemical attack (Hollen and Saddler, 1958).

2.1.3 Agents of Deterioration and its Preventive Conservation

The deterioration is any kind of undesirable changes brought in the properties of the materials because of the reactions, between the material of the object and the environment to which it is exposed. It is a natural process and is a kind of degradation. Deterioration cannot be stopped but the process can be minimized.

As mentioned by the Encyclopaedia of textiles (1959), "Textile objects are by their nature "soft", more mutable than many other designed objects, and more vulnerable (partly because of their nature and partly because of the uses to which they are put) to degradation and dereliction. Their organic nature and their interaction with the factors such as light, micro-organisms, acid and alkali composition, oxidation, air pollution, high temperature, changes in R.H., ageing, soiling, staining and insect attack make them weak, fragile, brittle and powdery (Bisht, 2010).

The concept of preventive conservation incorporates all actions and procedures that aim at prolonging the life of an artefact by slowing down its deterioration. A meaning of conservation is to enhance the life expectancy of an object and this can be done through preventive conservation measures also. Preventive conservation has been defined as the mitigation of deterioration and damage to objects through non-interventive actions, including maintenance of proper storage conditions, handling and shipping procedures, and emergency preparedness and response (NPS Museum Handbook, Part 1 ,2012).

Textiles are damaged by internal factors also such as chemical additives added during the manufacturing process. In most cases, several factors act together to cause damages to textiles (Kim, 2011).

The agents responsible for deterioration of any kind of textile artefacts have been discussed in detail below.

2.1.3.a Light and heat

Light plays a major role in the damage of textiles. It not only fades colours but intensifies the oxidizing progression in the fibers. Light is electromagnetic energy consisting of altering wavelength and intensity. Light becomes more affluent in energy as the wavelength becomes short. In the electromagnetic spectrum, the wavelength range of 400-600 nm accounts for visible light, 200 to 400 nm ultraviolet (UV) light and ahead of 760nm is for infra-red (IR).

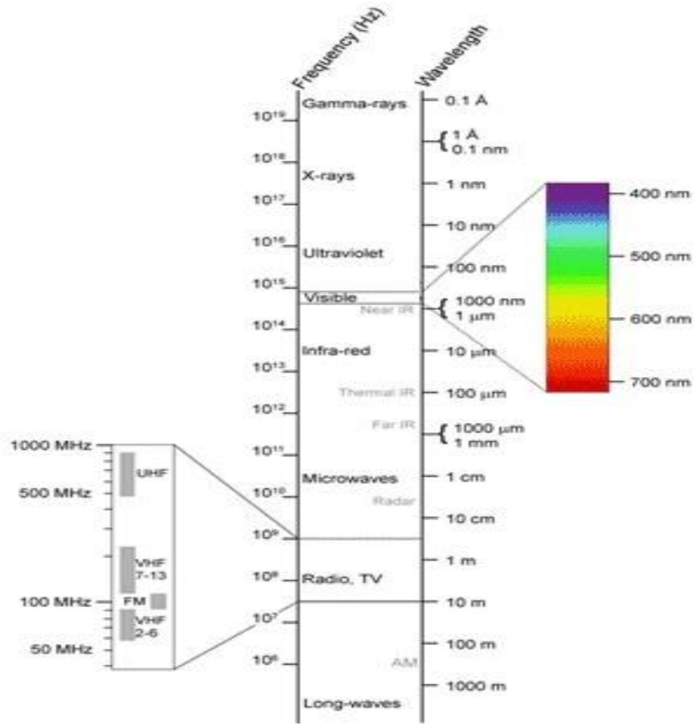


Plate 2.1: Electromagnetic Spectrum

Source: http://www.nedcc.org/free-resources/preservation leaflets/2.-the-environment/2.4-protection-from-light-damage

Light energy accelerates a photochemical reaction which causes weakening of fiber, a discoloration of dye/pigment and this process is called photodegradation. Resistance against photo-degradation comes in the order wool > cotton, hemp > silk, and silk are most vulnerable to light (Kim, 2011).

Damage due to light depends upon the following main factors: (a) Intensity of the light and (b) Duration of exposure and (c) Distance from the light source as more distance, less damage. Long exposure to light causes irreversible damage to organic materials, especially textiles. Therefore, limit the exposure to ultra-violet light by covering windows with shades, drapes or UV film. Keep light levels in the exhibit gallery at the lowest level that allows the visitor to see the object and labels comfortably. Try to use indirect lighting and do not focus it directly on the object. Cover all lights with UV filters especially fluorescent tubes.

Plate 2.2: UV Meter

Source:http://www.nedcc.org/free-resources/preservationleaflets/2.-the-environment/2.4-protection-from-light-damage

Heat generated from a light source can be another reason for damage. Excessive heat causes desiccation and embrittlement, too bright light and noxious gases cause the type of deterioration known as tendering (Plenderleith, 1956). Damage from heat leads to fiber weakening and colour change by disconnection of the polymer linking. It is the most appropriate to keep textiles at low temperature (19±2°C), if possible.

It is better to make use of the combination of daylight and artificial lighting. Wherever it is extremely needed to control light to its minimum intensity, it is better to use artificial light to avoid photochemical damage. Somewhere defused reflected light can be used. Zinc oxide or titanium dioxide can be used for coating a reflector. Various kinds of blinds can also be used to increase or decrease the intensity of daylight. Fiber optic illumination is more preferred presently. Sensor lighting is also preferred to minimize photochemical degradation. Therefore, we have to adopt that technology in an appropriate way for the benefit of the collection (Swarna Kamal, 1975).

The list of ultraviolet absorbing filters has also been recommended by the lighting group of the ICOM Committee, for conservation (Thompson et al, 1969).

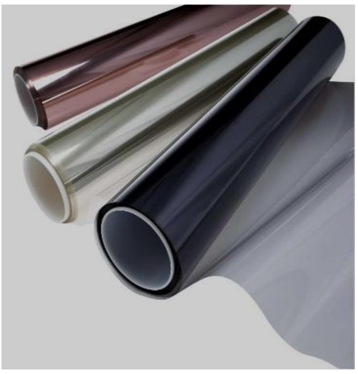


Plate 2.3: Window Films

Source:http://blog.srmi.biz/energy-saving-tips/energy-efficient-air-conditioning-cooling-cost/window-films/

Plate 2.4: Displayed textiles at Charleston museum

Source: http://www.charlestonmuseum.org/textiles-gallery

2.1.3.b Temperature and Relative Humidity

Most of the textiles are affected by excessive dryness resulting from high temperature and low relative humidity thus weakening the structure of the fibers and making them brittle. High relative humidity is also equally deleterious causing weakness to the fabrics, the growth of molds resulting in permanent staining and weakening sizing materials resulting in its loss (Bisht 2010). The moisture content in an environment mainly affects :

(1) Physical properties such as shrinking and swelling, density, electrical, thermal and acoustic properties, weathering and mechanical properties

(2) Reaction to biological agents such as bacteria, fungi, insects and marine borers and

(3) Technological properties and processes such as drying, preservative treatment, gluing, coating and consolidation.

It is important to maintain relative humidity at a certain range (45~55%) for the conservation of artefacts as changes in relative humidity affects the speed and extent of artefact's degradation (Kim, 2011). Extreme changes in temperature or humidity must be avoided at all times and it should be gradual. As a universal rule, temperatures be maintained at room temperature from 65^{o} to 75^{o}F. Storage areas can be as low as 65^{o} to 70^{o}F and if the exhibit gallery contains a door used by the public to enter and exit the museum, do not put artefacts at the opening of the door or entrance in order to avoid severe variations in temperature and humidity. Daily fluctuations in temperature and relative humidity should not be more than 3% (NPS Museum Handbook, 2001). Handheld hygrometers and data loggers can be used to monitor R.H. in galleries.

Plate 2.5: A hair tension dial hygrometer **Plate 2.6:** Electronic Hygrometer

Source: http://en.wikipedia.org/wiki/Hygrometer

A museum should discuss with a conservator and/or heating ventilation and air conditioning (HVAC) technician experienced with museum conditions in order to stabilize best conditions for its distinct acquisitions.

2.1.3.c Biological attack

Biodeterioration is one of the most commonly encountered problems faced by museum collection. Environmental conditions permit the growth of organisms. In India, for the large part of the year, the temperature ranges between 25^{0}-35^{0} C and the relative humidity remains higher than 70%, is very acute. These atmospheric conditions are highly conducive to the multiplication of insects and micro-organisms (Agrawal and Dhawan,1985). The climatic condition accelerates the growth and multiplication of living organisms. These organic agencies can be divided into:

- Micro-organisms such as Fungus or molds, bacterias etc.
- Insects
- Rodents

The biological agents that cause damage to textiles are mainly fungi and insects. Natural fiber is vulnerable to damage from the biological attack. Vermin and microbes breed in warm, dark and dusty environments where relative humidity is over 55%. They may stain, discolour, loss of coherence, attack on the lumen of natural fabrics and weaken them. Clothes moth lay eggs on soiled wool or silk and caterpillars hatch out of eggs and nibble away textiles and leave their excrement behind. Caterpillars of the carpet beetle also nibble away wool fabrics. Silverfish damages starched cotton or hemp because they feed mainly on starch. Mold feeds on cotton and hemp fabrics and they make black spots on the surface. Mold rapidly destroys fibers and makes holes (Kim, 2011).

Molds are minute fungi which grow on the surface of textiles. Fungi are capable of secreting certain enzymes with the help of which insoluble organic substances such as starch, cellulose, lignin, and protein are dissolved and absorbed. Therefore, they thrive on a large variety of museum objects. Cellulose fiber is more susceptible to fungus attack than protein fibers.

Textiles of animal origin are susceptible to insect damage more than ones made from the plant materials. Dr. S.M. Nair while he was in The Maharaja Sayajirao University of Baroda, Dr. Shashi Dhawan and others at the National Research Laboratory for Cultural Property, Lucknow, India studied and identified species which feed on woollen cloth (Lepidoptera). It survives on proteinaceous material such as woollens and dermestid beetles that attack woollens. The most common pest in India is the case bearing cloth moth, Tinea pellionella which destroys mainly woollen fabrics (Bisht, 2010).

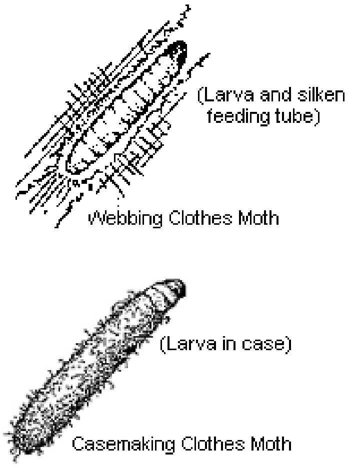


Plate 2.7: Clothes moth damage **Figure 2.1**: Clothes moth larvae

Source: https://entomology.ca.uky.edu/ef609

Insects are normally present in the natural environment and find their way into collections by means of the infected object or through trade and travel (Strang & Kigawa). Textile pests are also known as protein feeders. Textile or fabric pests are among the very few animals that can digest keratin, the primary protein found in animal hair and horn or chitin which forms insect bodies (Conserve O Gram, August 2008).

Caterpillar of corper beetle Clothes moth Silver fish

Plate 2.8: Fabric Pests
Source: (Kim 2011)

Traditional practices for the control of insect

According to Perumal (1996) citronella is a common ingredient in insect repellents sold over the counter at the chemist. Turmeric is also used as an insect repellent. Neem leaves, sandalwood powder, cloves, and peppercorns are packed in sachets and provide a fragrant and effective repellent, together with the sweet flag (Jasti Madhu) and camphor (to which little wax has been added). These sachets are replenished every three months with the ratio of the contents altered slightly each time to prevent insects from gaining immunity.

Fumigation and appropriate management of the environment is needed to protect textiles from vermin and microbes. Museum objects prior to display should be free from insects and their larvae. Textiles that are normally immune from insect attack should be isolated from vulnerable materials (Swarna Kamal, 1975). The studies on some biodeteriogens done by Shah (1997) investigated that aqueous leaf extracts of neem, Eucalyptus, Lantana and bel were effective against biodeteriogens which causes damage to museum objects. While exhibiting in showcases, various insect repellents like camphor and sulphur-free naphthalene balls and para-dichlorobenzene may be used. A mixture of chloroform, creosote and naphthalene (C.C.N. in equal quantity) known as British Museum Mixture is used as a repellent in display and storage of dry preserved zoological specimens. Nair (1972) developed a formula which contained paradichlorobenzene, benzene, creosote (PBC) in equal quantities. It was also found as an effective repellent, for dermestid beetles, cockroaches, clothes moth and termites (Agarwal and Dhawan, 1985). Swarna Kamal (1975) suggested the following formula to cure the fungus as well as insect attack on textile objects:

Naphthalene flake ...	...	100 gm
Sodium Pentachlorophenate	...	30 gm
Pyrethrum extract 2 per cent	...	20 c.c.
Ethyl Alcohol	...	1000 c.c.

This recipe was tested in a conservation laboratory of the Baroda Museum and found satisfactory. The author also reported that this mixture can also be sprayed on textiles as it does not cause stains on the specimens. White tissue paper impregnated with lindane, or D.D.V.P., etc. is useful if piles of textiles are to be protected. It should be inserted between individual pieces of fabrics. As the insecticidal life of this paper is very short, periodical renewal is necessary after a few months. Insect resistant wood for building materials and cupboards should be used. It is preferred that packing boxes, cupboards, frames for transit may be of deodar (Cedrus deodar), teak (Tectona grandis) and Indian rosewood (Dalbergia latifolia Roxb) which have insect repellent properties. Cracks in the cupboards and display cases may be sealed with a mixture of paraffin wax and beeswax and powdered insecticides like D.D.T., boric acid or pyrethrum, etc. dusted on them regularly. A variety of traps and lures are also available mentioned as follows [www.spnhc.org]:

- Sticky sheet traps, for flying insects for monitoring purposes.
- Monitoring traps, for crawling insects.
- Pheromone lures e.g. Storgard. Targeted at a specific species, e.g. clothes moth, cigarette beetle. An integrated pest management system (IPM) may also be utilized by museums to control pests.

Plate 2.9: Individual traps

Individual traps are place in corners and along walls, and checked monthly

Plate 2.10: Sheets of sticky traps

Sheets of sticky traps are available from pest extermination companies

Source: http://www.manitobamuseum.ca/main/conservation/2011/03/20/pest-monitoring-is-another-important-task/

Plate 2.11: Webbing clothes moth Trap Kit

Source:http://www.insituconservation.com/en/products/insect_traps/moth_trap_kit

2.1.3.d Air pollution

Pollutants in the air which deteriorate museum collection are sulphur dioxide, hydrogen sulphide, chlorine components, ozone and various nitrogen oxides. These are produced by industry and vehicular traffic. Occasionally they are naturally present in the air. Carbon-containing particles, as in soot, are produced in the combustion of fossil fuel or wood. They are increasing in quantity in industrial areas and developing urban centres, as they are used as alternative energy sources to petroleum oil. Soot particles have a highly absorptive capacity for gaseous pollutants, such as sulphur dioxide, producing a corrosive (acidic) form of dust. Dust accumulated on the surface of art objects or artefacts can be harmful if the particles are acidic in nature or if they are gritty and hard.

Textiles tend to absorb sulphur dioxide from the atmosphere which is converted into sulphurous acid responsible for wear and tear especially cotton is most affected. Wool and other keratinaceous materials release sulphide gases that increase with the rise in temperature, humidity and light intensity (Bisht, 2010). Risk of pollution can be minimized by keeping textiles away from all kinds of particulate matters. Sulphur dioxide is an impurity in the atmosphere resulting from the combustion of fuel. It readily forms sulphurous acid, which in turn is oxidized to sulphuric acid. It is the most potent cause of the tendering of textiles. Textile collections in cities or near the industrial area are likely to be best conserved when protected under glass (Plenderleith, 1956).

2.1.3.e Handling and Storage

i) Handling during transportation and study

Artefacts can be damaged when they are handled in an inappropriate way. Most of the damage to the museum is done by the mishandling and human neglect rather than the damage caused by natural agents of deterioration. The staff engaged in the handling of museum objects can be trained properly in that function so that the objects can be saved from damage. They have to follow certain basic principles of handling museum objects.

Never handle the museum objects with naked hands as there are possibilities of various stains due to perspiration and oil of the skin which may react with the material of the object and cause deterioration of the object. Always put a habit of wearing cotton hand gloves while handling the museum objects.

Plate 2.12: The use of gloves while handling textiles

Source: http://www.nma.gov.au/exhibitions/museum_workshop/conservation_at_the_museum

ii) Packing and shipping preparations while transporting

A lot of damage can occur during shipping. The shipping area should be near to the storage area. Unpacked objects should be ready to be transferred to preparation rooms for the display in the exhibition gallery. After the exhibition, the work should be returned to a similar storage area in preparation for final inspections and repacking. Aircraft fluctuations, vulnerability to bad weather, and accelerated fluctuations in relative humidity can damage objects. Decent preparation and transportation will restrict these and other travel risks including collision and quake, unexpected changes in warmth and moisture, mishandling, crime, destruction, and damage. Before moving a museum object outside of the building, consider all the factors that may harm the object and use good covering and wrapping materials which should include acid-free glassine, tyvek, tightly woven nylon fabric, cotton knit, soft unbuffered acid-free tissue paper, mylar, blanket pads or quilts and acid-free folders (NPS museum handbook, Part I, 1999).

Plate 2.13: The proper way to lift and carry a small textile object.

Source: NPS museum handbook, Part I (1999)

iii) Storage environment

Once the object comes to the museum it requires space for storage and then spaces for exhibits. The basic principle of storage is to keep the object in a physically secure environment which requires acquired and controlled condition such as relative humidity, temperature, and light. Empty packing cases should be properly stored under a controlled environment. The storage area may house a variety of objects requiring different degrees of R.H. control or light protection. The preferred lighting system for storerooms is incandescent which is low in ultraviolet radiations. It is good practice to turn off lights when the storage area is not used and also to control daylight at windows with shades or suitable screening materials (Stallow,1987). To save from dust and dirt accumulation, the plastic material should be loosely draped over the object, not enclosing it completely but allowing for air circulation and hence humidity exchange with the environment. Insect control is essential in the storeroom. Fumigants such as naphthalene flakes and paradichlorobenzene (PDCB) should always be stored with woollen textiles.

Regular inspection of light readings, temperature readings, relative humidity and air circulation is necessary. Three-dimensional objects if left on the floor should be placed on dollies or temporary platforms to permit handling and lifting. Shelving may be of either wood or preferably metal construction for storage of two or three-dimensional objects. It is important to avoid shelving which is too high or too deep to make reaching and access difficult and hazardous. The surface of shelving should not be too smooth and prone to accidental slipping or shifting. Drawers are used for flat and small objects. Compaction device is recent equipment in the museums used for more storage in less space. The storage area should have a good security system and facility. The storage should have a fire extinguisher at the appropriate place so that it can be easily approachable and easily available at the time of emergency.

iv) Materials for storage

All construction materials should be made of inert materials or sealed with coatings that are water-based. Mounts should implement security and safety for an artefact, however, be as undetectable as possible.

All construction materials used for cases and platforms should be free of acid and other harmful volatile materials. If plywood requirement is there, choose either the marine category surface plywood AA or BB, or MDO plank designed with latex paint. As an anticipation, when using any timber, seal it with a water-based polyurethane sealant or high-quality latex paint. After painting, curing is done for a minimum of three weeks before any artefact is placed. The case should have ventilators to allow air exchange. Only inactive materials should touch an artefact. Do not place an artefact directly on an unbalanced cover. Appropriate buffers are used such as: mylar, brass (cover brass with shrink tubing), ethafoam, plexiglas, undyed cotton or linen, acid-free paper or board and formica.

v) Boxing material

Always use stable materials when boxing artefacts. All cases should be made of acid-free, archival element which may be obtained from several suppliers such as Gaylord University Supply Talas Light Impressions. Textiles that stay stored in cases should have a few pleats as possible. Size of the box should be appropriate to the artefact. Do not "stuff" the artefact into a box that will injure the item in the long run. The box should be lined with acid-free tissue and fill any folds in textiles with acid-free tissues by making sausages. The surface of the box should be labelled with its contents. The layering of the garments in the box should be avoided. If possible, place the most fragile textile objects on top.

The historic fabric is generally made from natural material like cotton, linen, silk or wool. Textiles are delicate and are easily damaged by faulty methods of handling and storage. As far as the possible folding of textiles should be avoided because the textiles get weaken at the folds and ultimately tear. They should preferably be stored on rollers or tubes, of which the ends project beyond the textiles in order to protect them from damage (Agarwal, 1977).

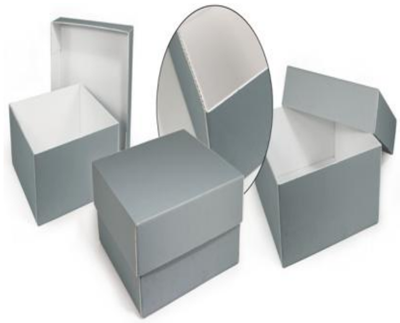


Plate 2.14: Acid free storage boxes

Plate 2.15: Textile rolling and storage tube

Source:

http://apps.webcreate.com/ecom/catalog/product_specific.cfm?ClientID=15&ProductID=23451

The experienced conservator should be consulted for guidance in developing an acceptable storage area. Always use both hands for handling purpose. Never lift the objects with their projecting part because they are delicate and there are possibilities for the cause of their physical damage. Use wooden trays and trollies with enough cushioning (padding) material (for example, polyethylene foam or acid-free tissue) so that, at a time many objects can be transferred with a great care. Textiles should not be piled one over the other and when transporting them to the laboratory or the photo studio or to the packing areas, the textiles must be supported from beneath ensuring their safety. Acid-free tissue spacers should be used on the front side. Hangers made of good quality plastic with suitable padding can be used for costumes and dresses (Bisht, 2010).

Plate 2.16: The use of padded hangers while storing costumes

Source:http://www.powerhousemuseum.com/insidethecollection/tag/textiles/

The ordinary paper contains acid residues that may cause deterioration of fiber. Items should not be stored in plastic bags because these bags will deteriorate and release substances that may harm the fabrics, a phenomenon referred to as off-gassing. Ideal temperature (70^0F) and relative humidity (60%) should be maintained (Collier & Totora, 2001). Canadian Conservation Institute (CCI) recommended acceptable materials as under:

- acid-free mat board (buffered and unbuffered), made from either 100% rag or highly purified wood pulp, referred to as alpha cellulose.
- corrugated or fluted plastic board (e.g. cor-X, coroplast, poly-flute), made from polypropylene or polypropylene/polyethylene acid-free foam boards (e.g. fome-cor, Art core), which are sandwiches of foam, usually extruded polystyrene foam, set within the paper or plastic sheets.
- wood or wood products (but only if they are sealed with an aluminium barrier foil such as marvel seal).
- needle felted polyester felt or batting.
- prewashed fabric.

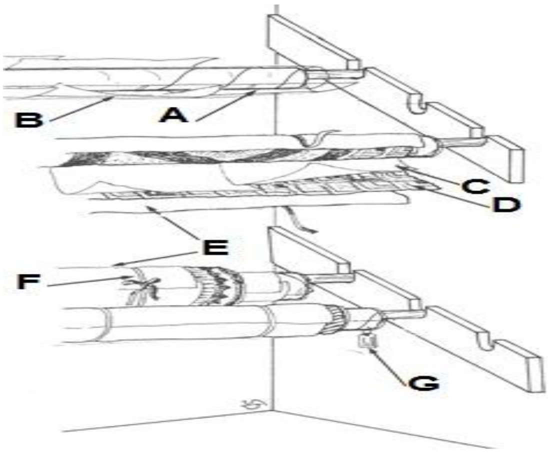


Figure 2.2: Bracket storage system (in a cupboard). A. Mylar covering a tube B. Acid-free tissue or prewashed cotton sheeting over mylar C. Interleaving of neutral-pH tissue or prewashed cotton sheeting D. Textile with pile on outside E. Prewashed cotton cover F. Cotton tape G. Identification tag

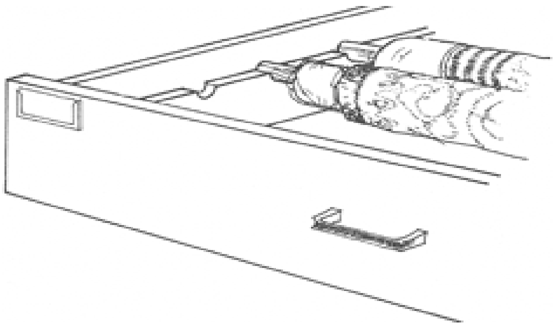


Figure 2.3. Bracket storage system (in a drawer).

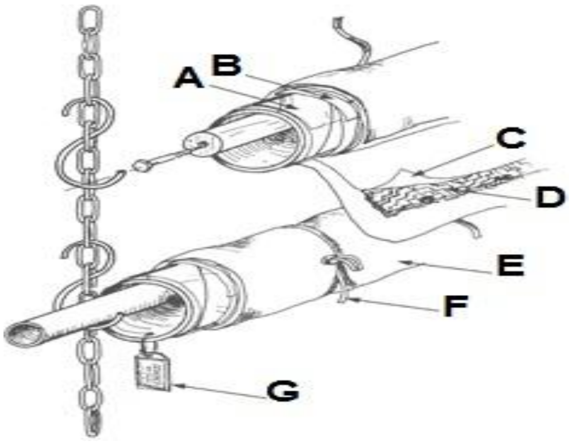


Figure 2.4. Suspension storage system. A. Mylar covering tube B. Acid-free tissue or prewashed cotton sheeting over Mylar C. Interleaving of neutral-pH tissue or prewashed cotton sheeting D. Textile with pile on outside E. Prewashed cotton cover F. Cotton tape G. Identification tag

Source: http://www.cci-icc.gc.ca/publications/notes/13-3-eng.aspx

NPS Museum handbook (2001) recommended storage materials that included cotton or polyester batting in plastic or muslin bags, polyester felt, bubble pack or air cap for padding of textile. Bisht (2010) suggested "Ageless Z" which maintains low oxygen atmosphere in a sealed showcase or storage space. This can also check the growth of the biodeteriogens on textiles and are user-friendly.

Plate 2.17: Rolled storage of textiles in drawers

Source: http://www.ellisfiling.com/index.php?url=utilizing-museums

Plate 2.18: Rolled Textile Storage on Shelving racks

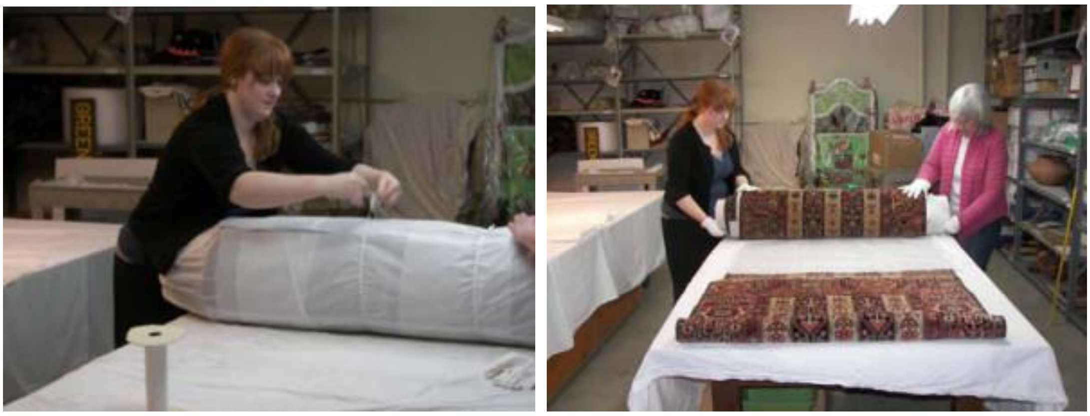


Plate 2.19: Rolling rugs for storage in acid free tissue papers

Source:http://nevillepublicmuseum.wordpress.com/2012/04/20/rolling-rugs-for-storage

2.1.3.f Display of shawls

Antiquities are very rarely displayed in the historic area due to the rigors of open display and their irreplaceable nature. While displaying a shawl never pin or tape anything to it. Inspect the collection for pests, especially the woollen artefacts. Display the large flat shawls on a muslin covered panel tilted at a slope. This avoids putting stress on the artefact if it is displayed vertically. Do not allow the shawls to come in direct contact with glass. Any support method that displays a shawl must be well stuffed in the spaces where weight from gravitation occurs. Always keep the shawl collections on rotation for display at certain intervals so that a single piece does not face problems of severe deterioration. The display in Calico Museum of Textile, Ahmedabad is a good example of display technique and application of appropriate lighting.

2.1.3.g Housekeeping

Museums should have a routine schedule of basic cleaning that includes sweeping, vacuuming, eliminating clutter, and trash. Careful consideration of commonly used visitor areas, such as restrooms or entryways, will improve the institutions' experience for the visitant. A calendar should be kept for cleaning the artefacts and display cases. Due to the delicate nature of many artefacts, museum employees should discuss with a conservator for appropriate conventional cleaning techniques suitable for particular artefacts. Housekeeping is an integral part of the preservation of museum collection. It is known to all that the most of the damage or deterioration caused to museum objects is because of poor housekeeping. Periodical cleaning within the gallery and store is an essential part of preventive conservation. Use of doormats and coir mats at the passages leading to the galleries is essential to minimize the entry of dust and dirt. It is equally important to keep the outside area of the museum neat and clean. The green environment around the museum and the use of eco-friendly materials in a museum help in the preventive aspect of preservation. It will be better to use vacuum cleaner rather than using a broom to clean the floor so that one can collect the dust and throw it outside the museum building. Cleaning with a broom is nothing but a transfer of dust from one place to another. The clean museum not only gives a pleasant look but also give psychological effect to the visitors and because of the pleasant environment, visitors would like to stay within the museum for a long time. Good housekeeping is also prolonging the life of the objects by providing a better environment to the objects. Biological agencies cannot cause harm when objects and galleries are enough clean.

2.1.3.h Disasters

In museums, there is a likely-hood of fire as the collections are mostly organic in nature. Once fire starts, it is difficult to save those materials which get fire. Items not directly engulfed in flames can be charred by soot and smoke. Heat emitted from the fire causes bindings to shrink and warp and plastic base materials to melt. Water used for fighting the fire can cause enormous damage. Flooding, fire, earthquake and civil disturbances are among the sudden calamities that potentially can strike museums and other collecting institutions. All the agencies can completely damage museum objects. Effects of disasters on collections are too obvious to comprehend.

1. Flood water can arise problems like

a) Deposition of mud and dirt.

b) They become so fragile, that even their handling becomes very difficult, as they remained submerged in flood water.

c) These will lead the fabric to absorb water, swell, warp and become extremely vulnerable to physical damage.

d) The anaerobic situations, chemical decompositions by hydrolysis and structural changes.

e) Water causes distortion, shrinkage, water stains, stains formed by water-soluble dyes and pigments.

Fire

A fire can destroy entire collections and, in some situation, it leaves burn marks on the surface of the artefacts. The burns marks become difficult to treat in case of textiles. There are various reasons responsible for the occurrence of fire in museums. The museum fire incidents have been on increase now a days because of two principle reasons:

a) The presence of combustible material which too often is an unnecessarily large quantity and lacked protective measures.

b) The delay in discovering and reporting fires.

c) Due to electrical short circuits because of improper maintenance of all electrical wirings periodically.

2.1.4 Remedial Conservation Processes

The processes of preservation, conservation and restoration are applied to safeguard the materials from further decay and deterioration. Preservation is the method in which all operations are conducted to monitor and delay deterioration whereas conservation includes proper investigation of the decayed matter, appropriate remedial approach and suitable prevention from further decay. Moreover, there are two aspects of preservation of materials:

(i) The preventive measures which include all forms of indirect actions aimed at increasing the life expectancy of undamaged or damaged elements of the cultural property. It comprises all the methods of good house-keeping, caretaking, dusting, periodical supervision, and prevention of any possibility of damage by physical, chemical, biological and other factors.

(ii) The curative measures consist of all forms of direct actions aimed at increasing the life expectancy of undamaged or damaged elements of the cultural property. It includes patching, repairing, fumigation, de-acidification, lamination, and other works which are required considering the physical condition of the particular record. Conservation can be defined as any activity required to maximize the endurance or minimize the deterioration of any cultural property as far as possible and includes examining, testing, treating, recording and preserving any such cultural property or any part thereof.

Conservation treatment described as the deliberate alteration of the chemical and/or physical aspects of objects, aimed primarily at prolonging their existence. Treatment may be categorized as stabilization or restoration (NPS Museum Handbook, Part 1, 2012).

According to ICOM, conservation, remedial conservation and restoration can be defined as follows:

Conservation as- all measures and actions aimed at safeguarding tangible cultural heritage while ensuring its accessibility to present and future generations. Conservation encompasses precautionary maintenance, curative preservation, and recovery. All steps and procedures should value the importance and the material properties of the cultural inheritance.

Remedial conservation as - all operations undeviating implemented to an article or a group of articles directed at capturing prevailing damaging methods or strengthening their fabrication. Certain operations are only conducted when the objects are in such a frail state or decaying at such a speed, that they could be spent in a comparatively short period. Those actions seldom modify the condition of the articles.

Examples of remedial conservation are disinfestations of textiles, desalination of ceramics, de-acidification of paper, dehydration of wet archaeological materials, stabilization of corroded metals, consolidation of mural paintings and removing weeds from mosaics.

Restoration – all actions directly applied to a single and stable item aimed at facilitating its appreciation, understanding, and use. Certain operations are only conducted when the article has suffered part of its importance or purpose through past modification or degeneration. All are based on regard for the fundamental material. Usually, such actions mitigate the appearance of the article (http://www.icom-cc.org, 2008).

2.1.4.a Conservation documentation of the artefact

Conservation documentation can be interpreted as the textual and visible credentials obtained through the supervision and handling of an article. It can include records of the object’s condition, any treatment done to the object, any observations or conclusions made by the conservator as well as details on the object's past and present environment. (www.jcms.ucl.ac.uk).

i) Examination report/ condition report

Documentation should be done for each article that has been produced in the preservation lab preceding to having any operation. At this time the existing condition of the object should be recorded and if it has not been done at some previous time or if gaps in knowledge seem to exist, the material composition and technology used to manufacture the object should be documented. Additional documentation on the condition of the object should take place after the completion of any conservation work. Observations and thoughts about any technological and art historical information that is uncovered in the course of examination should also be documented. In this report, the environmental and storage conditions in which the object is kept should also be recorded along with the recommended ideal conditions (Moore, 2001)

A condition report is a record of that state in which the object is found. Traditionally, information is recorded by filling in a condition card accompanied by photographs, but it can also be gathered by a variety of means including a tape recorder, video recorder or digital camera linked to a computer. Information gathered should be documented methodically; physical, chemical and biological damage should be noted and where possible the source of the problem should be identified.

The nature and extent of the damage can determine the future role of that object within the collection, whether it can go on display, be loaned, be made available for consultation or be removed to storage until such time as conservation treatment can be carried out. An object should be flagged if it has particular storage requirements or needs further conservation treatment.

The example condition report provided here is general to most objects and is fairly self-explanatory. Although quite detailed, it shows the approach most likely to take by a conservator. It might be more helpful at a later stage, to draw up a condition report specific to a type of object i.e., furniture, books, paintings, etc. To correctly identify the range or type of damage, the services of a conservator must be used.

Finally, apart from recording the current condition, an object may be given an overall condition rating in terms of priority of attention.

CONDITION REPORT

Object
Cat. No.

Date of object
Location

Artist/manufacturer
Dimensions, Labels, Identifying Marks:

Materials/media:
Present storage system:

Damage description

Physical damage

i. Major structural damage: (e.g., parts detached, broken. tears, fractures, pieces missing, holes)
Suggest cause \ source:

ii. Minor structural damage: (e.g., small tears, holes, creases, folds, loose parts, etc.)
Suggest cause \ source:

iii. Surface damage: (abraded \ scratched surfaces, delamination, cracked glazes)

Chemical damage: (acidity in textiles, corrosion of inks, encrustation, tarnishing of metals and crizzling of glass)
Suggest cause \ source: (internal or contaminant.)

Biological damage: (e.g., rodents, pests, mold, and mildew)
Suggest cause \ source:

Previous Repairs:
Surface accretions and disfigurements: (e.g., soiling, stains, dirt, deposits, cello tape, staples, discoloured adhesives, discoloration, and fading)

Further comment or recommendations:

Condition rating: (good, fair, poor, or do not handle)

Treatment priority: (urgent, high, medium, low)

ii) Photographic Documentation

Photographs should record the original condition as well as changes made during treatment. Photographs should be taken in ambient brightness, and in other light conditions to present appropriate data, such as perversions (raking light), or auto-fluorescence (UV light).

Photographs should incorporate:

- Overall front and back views
- Parts of damage.
- Before and after shots of the conserved regions, and feature shots of the maintenance operation.
- Photomicrographs, if applicable. (www.conservation-wiki.com)

According to H.J. Plenderleith and A.E.A. Werner, before starting any restoration work, the preparation for the examination of textiles should be done. The things which can be used for preliminary examination are magnifying glass, binocular, camera, microscope, watch glass, swab stick, cotton, distilled water, thread counter, tensile strength tester (if required) and optivisor.

Depending upon the problems all the equipment should be laid on the work table minimizing the frequent movements by the conservator during conservation. The things such as soft brushes, white petrol, steam vaporizers, spray bottle, blotters, melinex, swab stick cotton, threads, needles, mini vacuum, thickness gauze, camera, hand microscope, treatment record sheet, pencil, scale and tweezers should be kept.

A workspace is needed. It should be large enough to lay the item out completely. A large dining table can be used or a clean floor space covered with a large, clean, white cotton sheet (www.archivalmethods.com).

2.1.4.b Checking for colorfastness and fixing the dyes/ink

The coloured shawls, however, be checked for their colorfastness. Each colour should be checked separately by keeping a blotter at the bottom of the shawls in order to check any fugitive dye. Fugitive dyes are fixed by immersing the artefacts in the solution of 0.5% common salt (Plenderleith, 1956).

i) Cleaning of textiles

There are two forms of cleaning for historic textiles.

- Mechanical cleaning

Cleaning is the action of removing extra-unwanted material from the original material. It is a kind surface cleaning in which dust or small particles of soiling are removed physically. Large contaminants can be removed with tweezers and small particles can be brushed off and removed with a vacuum cleaner. The brushes of various types and sizes can be used for brushing. It should follow the weave or pile direction (for velvet or carpets). A blower can be used to remove dust in dense areas such as between embroidery or gem decorations. When using a vacuum cleaner on the damaged artefact, a net screen is needed to cover the surface of the artefact for protection (Kim, 2011).

Plate 2.20: Proper vacuuming technique. Loop the vacuum hose over your arm to keep from dragging it across the textile. Place the brush down on the surface of the screen. Lift the brush to move it to the next location (do not rub the brush back and forth across the screen).

Source: NPS Museum Handbook Part 1 (2002)

Dry sponges are also in use for the textiles cleaning at the conservation laboratories in India.

Plate 2.21: Dry chemical sponge and used bits during cleaning

Source: http://textileconservation.academicblogs.co.uk

- Wet cleaning

Water washing is one of the most effective methods of cleaning historic textiles and can be improved still further with the addition of detergents to the wash water. Solvent cleaning is done when an aqueous treatment is not suited to the object. Kim (2011) states that 'dry cleaning' is a commercial term meaning the soil removal using solvents. Very strong solvents are used in most of the cases. This process is called 'solvent cleaning' in conservation treatment. Solvent cleaning removes oily stains of oil, resin, wax, varnish, etc. from the textiles.

In case of frail textiles, a porous support is used instead of polythene sheet, so that while wet washing, the water and dirt can drain through the textile. The material may be sandwiched between two sheets of terylene net fixed in a frame so that handling is reduced to the minimum. After washing, the terylene is pressed between warm dry towelling to remove excess moisture and when partly dry the frail material is transferred to a polythene and pinned out (Plenderleith, 1956). However, today fewer textiles are wet cleaned. The techniques of wet cleaning have also diversified; the active properties of surfactant foam are sometimes now utilized as an alternative to the mechanical action used in traditional wet cleaning, while vacuum suction table is widely used to clean fragile textiles safely and to prevent dye bleeding (Lennard & Patricia, 2010). In case of washing the open weave shawls, they should be pinned down or tacked by the thread to a sheet of polyethylene in order to safely wash the textile. Since animal fibers are very much sensitive to warm water, their contact with hot water should be avoided. The fibers should not be rubbed vigorously against each other as they tend to lose their lustre. Cleansing agents should be used in water for cleaning certain woollen textiles. The woollen artefacts should never be kept with the collection unwashed as these are more prone to insect attack due to the soil and perspiration. Steam cleaning/

humidification is another option for wool textiles rather than washing the whole article i.e. immersing it in liquid and distorting its shape (Plenderleith 1956). Lennard (2010) also suggested the same as 'humidification' which has become a common treatment, used to reduce creases if wet cleaning is impossible.

Plate 2.22: The before and after cleaning photo of Suzani embroidery

This suzani embroidery, a textile from the collection of the Museum of Decorative Arts, Paris, was initially cleaned on the automated installation; however, the textile appeared only slightly cleaner due to the fineness of the weave of the support. It was then cleaned a second time on the vacuum cleaning table which allowed for a localized treatment of the dirt and stains. The latter was removed by the use of solvents and surfactants.

Source: http://www.chevalier-conservation.com/en/nettoyage/avant-apres-nettoyage-textile_en.php

ii) Stains removal

The first step in the removal of stains is to understand the nature and composition of the material of textile. The nature of the substance causing the stain should also be known before treating the kind of stain on textile. Vacuum suction table is used to reduce staining caused by fugitive dyes. There are solvents recommended for removal of different kind of stains. Uniyal (1980-81) suggested the following:

Table 2.1: Types of stains and reagents

Type of stains	Reagents
Copper corrosion	Ammonium hydroxide
Iron rust stains	Disodium salt of EDTA, formic acid, acetic acid, oxalic acid (0.5 % to 1%).
Grease or wax	Turpentine, benzene or trichloroethylene
Old oil paint	Acetone, tri chloro ethane, terpentine or cellusolve
Blood stains	Fresh stain- synthetic detergents in water Old blood stain- bleached after washing with detergent solution. For bleaching- hydrogen peroxide with few drops of ammonia
Mildew stains	Bleaching agents used - chloramine T (2% in water) potassium permanganate (1% in water) & hydrogen peroxide
Writing ball point	Isopropyl alcohol or trichloroethylene
Red ink	1% ammonia with water or methylated spirit

The reagents which can be used while dealing with wool fibers are dilute alkalis and hydrogen peroxide. As far as the bleaching of the shawls is concerned it should be avoided as much as possible on the protein fibers especially the old and frail shawls. For the cleaning of stains hydrogen peroxide along with little ammonia is used (Plenderleith, 1956).

Stain removal is not a good idea when dealing with the old textiles. It should only be done if the textile is strong enough to withstand it. Therefore, it is done preferably on the contemporary textiles. The grease stain is removed by covering both sides of stain with the blotters and applying the warm iron over it. It was seen that as the grease melts, it gets absorbed in the blotters leaving the residue behind which can then be cleaned with trichloroethane. Mud stain can be cleaned mechanically with the help of the scalpel (Plenderleith, 1956).

iii) Reinforcing or strengthening of textiles

Many textiles undergo organic damage as a consequence of loss or natural decay processes. The consolidation of damaged textiles can be achieved through the application of the broad range of support techniques, from stitched repair to adhesive techniques.

If the textiles are too frail or brittle that they cannot be stitched, then their fragments may be preserved in plastic envelops without giving any conservation treatment. These fragments can be exhibited by placing them on a sloping surface in a dust-proof exhibition case; the surface should be faced with rough silk or velvet with a pile facing upwards so that textiles fragments remain to adhere in position (Plenderleith, 1956).

a. Support technique

The lining is an important step while reinforcing fragile textile. It is a protective backing applied to an unlined textile in order to protect it from airborne pollutants, including dust and dirt, as well as the risk of insect infestation. The commonly used fabrics are:

- Sheer fabric, including nylon net, silk crepeline, or polyester Tetex (Stabiltex), are typically used for overlay treatments or treatments combining overlay and backing.
- Nylon net-heat-set or bobbinet-constructed

Beecher (1963) described an extension of the method of reinforcing weakened textiles by sealing them to a supporting fabric of the plastic net. In order to secure the maximum degree of contact between the fragile material and the supporting net, they are held together by a permanently flexible adhesive. The filaments of the net were coated with an internally plasticized polyvinyl acetate emulsion, which was allowed to dry; the weak fabric was then placed upon the net and light pressure with a heated iron caused it to adhere. A reference to mounting a fragile textile by applying momentary heat which should not exceed 110^{o}C attracted sharp criticism as being drastic and damaging. It was true, of course, that to expose textile fibers to excessive or prolonged heating must injure them; but it may be said with equal certainty that the majority of old fabrics has suffered much more damage from ordinary expose to light that would be caused by momentary contact with a degree of heat a little above the temperature of boiling water. Happily, however, the degree of heat required to effect adhesion between the prepared tulle and the weak fabric was mild and needed no more than about 70^{o}C.

b. Stitching technique

Threads and yarns were used for stabilization through repairing (e.g., darning, reweaving), reuniting of parts (e.g., restitching of seams), attaching the textile to a local or overall support fabric, securing weak areas of the textile or losses to the backing (e.g., couching) and stabilising edges (e.g., attaching loose fringe or other trims, rebinding edges). (www.conservation_wiki.com). Some of the stitches used in textile conservation are as follows:

1. Self-couching stitch: The self-couching stitch is used to secure torn, frayed, or weak areas to a new support fabric, and is consequently the most frequently used stitch in textile conservation. This stitch is formed parallel each through the warp and the weft. As illustrated in Figure 2.5a, the long stitch is laid first and extends into the stronger area surrounding the damaged area under repair. This stitch is then held down by small stitches

that cross it at right angles (Figures 2.5b and 2.5c). This method is reproduced at frequent interludes till the weak area is correctly secured. Please note that these tiny stitches should be spun along the lateral running stitches in order to avoid forming any prominent design.

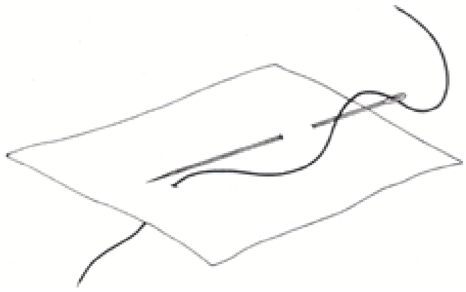


Figure 2.5a: A long stitch is made first. It starts and ends in an entire area of the textile and crosses the weak or damaged area. Lining fabric and degraded area of textile not shown.

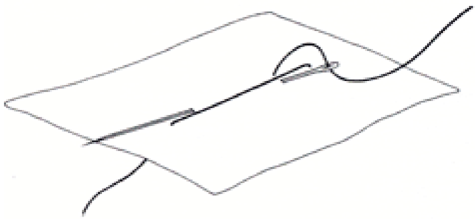


Figure 2.5b: Small stitches hold down long stitch

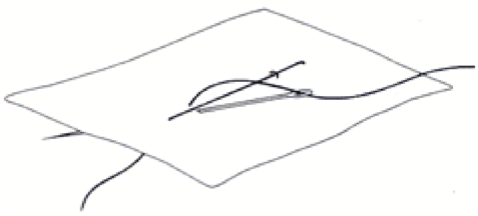


Figure 2.5c: Small stitches cross long stitch at right angles

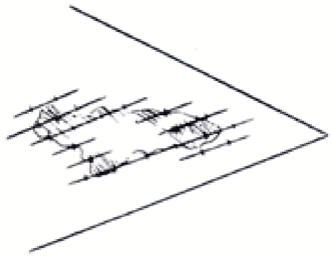


Figure 2.5d: Damaged area of a textile that has been secured to its backing fabric by a series of self-couching stitches.

Figure 2.5: Couching stitches

2. Support stitch

This stitch is used to hold large textiles to a new backing fabric while distributing the weight of the textile evenly (Figure 2.6). A minute, almost hidden stitch is formed on the top of the textile and a running one is formed on the rear. Most commonly, the support stitch is implemented in a staggered design parallel to the loom.

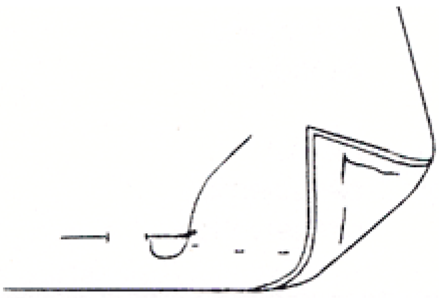


Figure 2.6. Support stitch.

3. Herring-bone stitch

This simple interlacing stitch, similar to a cross-stitch, is worked from left to right and secures raw edges (Figure 2.7). The herringbone stitch can be applied to secure two folds of textile while sustaining extensibility. It is also frequently used to hold down single-fold hems or the edges of patches.

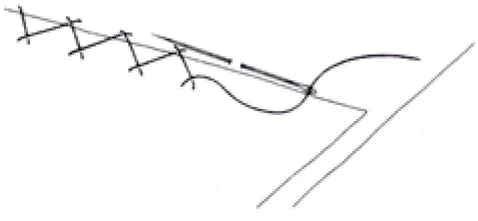


Figure 2.7. Herring-bone stitch.

4. Slip Stitch

This slip stitch is nearly obscure on the right side. It is used for blind hemming (Figure 2.8) and to attach linings to textiles. If formed loosely, it avoids unwanted tautness between the lining material and the textile.

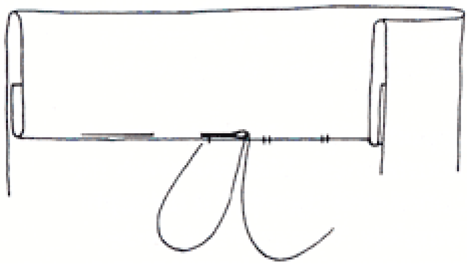


Figure 2.8. Slip stitch.

5. Whip Stitch

When more than one width of fabric is needed to back a textile, a whip stitch is used to join the two selvages, as illustrated in Figure 2.9a. When the fabric is opened up, as in Figure 2.9b, a flat butt joint is created that avoids seam build up.

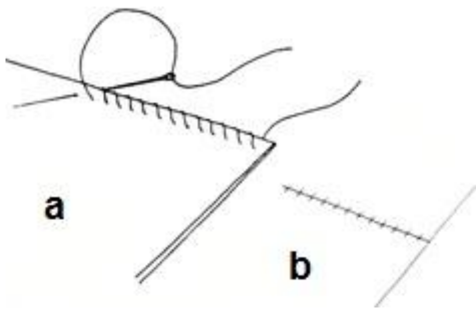


Figure 2.9a and 2.9b. Whip stitch

Source: https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/canadian-conservation-institute-notes/stitches-textile-conservation.html

c. Adhesive techniques

As the general principle, modern techniques were used for the repair of old textiles whenever possible, as this made easy to distinguish between what is old and new. In most cases, a heat-sealable adhesive, such as polyvinyl acetate, polyvinyl alcohol, acryloid B-72 or their emulsions were used to coat the backing which is then ironed (heat-sealed) onto the textile. Any breaks in threads either in the warp or weft of the material should be affixed with drops of glue to prevent additional unraveling. Resins used in adhesive support were classified into the natural material and synthetic material. Natural adhesives starch, glue and synthetic resins such as cellulose ether (klucel G), polyvinyl acetate (mowilith DMC2, vinamul 3252), ethylene vinyl acetate (beva 371), and acrylic resins (paraloid B72, lascaux 360HV, lascaux 498HV) were commonly used (Kim, 2011).

iv) Mounting

The main purpose of mounting is to protect the artefact so that it can be preserved in the safe condition after the treatment. Flat textiles can be stitched on a padded board or fixed in a frame. The mounting board consists of a hard bottom layer, middle layer absorbing shock and a cover fabric. Cardboard, honeycomb board, corex board, or wood board (for large artefacts) are used for the bottom layer. Polyester felt or polyester wadding is used for the middle layer. For the cover, various natural or artificial fabrics are used and appropriate textile material that will not cause damage in artefact should be selected (Kim, 2011).

There has been a great improvement in the range of chemically inert mounting materials available to the textile conservator in the last 10-15 years. A range of materials such as ethafoam, plastozole, expanded polyethylene foam and correx, a corrugated polypropylene board, is commonly used for creating storage and display mounts (Lennard, 2010).

2.2 Research Review

Brennan (2008) undertook an experimental research project for the anoxic storage for textile collections in Bhutan. The project's goal was the augmentation of the storage facility into a protective environment by creating anoxic micro-climates for the long-term preservation of textiles. Research for the anoxic system was done through technical searches and in consultation with private and institutionally based American conservators as well as with material suppliers. The six material supplies needed to implement the anoxic microenvironments were Barrier film (multi-layer laminate film), "Ageless" Oxygen Absorbers/ Scavengers (ferrous oxide, the chloride salt, and a humectant), "Ageless" eyes or indicators (optional), heat sealer, nitrogen gas & regulator, and vacuum cleaner.

The fundamental systems of anoxia were extremely suitable for the specific needs of the project in Bhutan. The heavy plastic barrier film envelope remains an effective physical barrier even if the oxygen levels within the enclosure rise. The enclosure protects the contents from water damage and smoke. Both are prevalent causes of deterioration in Bhutan's homes and monasteries. Moreover, the packages would protect the actual artefacts from excessive handling, skin oils, and soiling. Because this system would effectively "seal up" the artefact in transparent film and not permit free access or handling, the need for building a photographic and detailed database was part of the overall project. Constant and reduced oxygen environments were created by making a sealed environment and displacing the air or oxygen in it with an inert gas. If the level of oxygen is maintained at less than 0.05%, then pests cannot survive, and most other aerobic biological growth is destroyed or halted, (Burke 1999). Oxygen scavengers or absorbers can be left inside the sealed system to ensure that any additional oxygen is consumed. Film bags have to be cut open to provide physical access for examination, and then either resealed (this can be done a number of times until the bag is too small), or new bags made and the artefacts repackaged. (In two years, 24 bags have been opened and resealed). 50 textiles were re-housed within microclimates through the training period in 2005. Purging with nitrogen was essential to the success of the system, as it created full volume bags for delicate textiles and better ensured the 0.05% oxygen level aimed for.

Plate 2.23: Removing oxygen from film bag with vacuum and Y hose

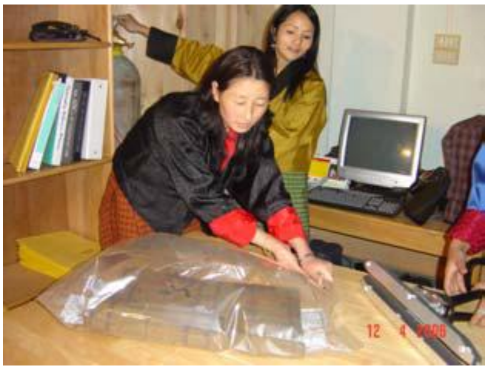


Plate 2.24: Purging the bag with nitrogen

Source: www.caringfortextiles.com

This small-scale experiment has accomplished its short-term goals of protective storage and expanding the program of preventative conservation at the Textile Museum. The anoxic system has been adopted, well executed and was expanded in 2008. This sets a successful example for other museums in the country, as well as providing options for extensive pest eradication for a variety of cultural artefacts. The anoxic storage method proclaimed the prime time to use a high-tech system in Bhutan for cultural preservation. The scientific novelty was championed in the local press and by the government agencies.

Duff *et. al.* (1977) carried out an experimental research tests to assess the washing fastness of some natural dyestuffs on wool under standard conditions ($50^{o}C$) and also at ($20^{o}C$) with a washing formulation used in conservation work on ancient textiles. In this research, the necessity of knowing accurately the pH of the alkaline solution for the cleaning of textiles dyed with natural dyestuff is highlighted.

For the experimental procedure, a range of natural dyestuffs have been applied to wool, and the wash fastness assessed by standard methods. The washing conditions specified are much more severe than those applied to ancient textiles, and the dyestuffs varied in their ability to withstand them. For the wash-fastness testing, samples of the various dyestuffs were dyed (on wool) using appropriate metal salt mordants, and as far as possible the methods employed in former times. The most common salts used for this purpose are those of the transition elements, chromium, iron and copper, and tin and aluminium. Dyestuffs and mordants used were Logwood/Cr, Logwood/Fe, Persian berries/ Sn, Indigo, Cochineal/Sn, Lac/Sn, Alizarin/Sn, Alizarin/Al, Fustic/Sn, Sulphonated indigo, Quercitron/Sn. Indigo is a vat dye applied by a reduction-oxidation cycle in which the insoluble colouring matter is chemically reduced under alkaline conditions to a soluble form which dyes the fiber. With mordant dyes, the metal salt can be applied separately before or after dyeing (two-bath method) or along with the dyestuff (one-bath method). The pre-mordanting two-bath technique was the preferred one formerly due to the better wash fastness obtainable as compared with the one-bath method. In some cases, long processing times were employed to ensure complete complexation of dyestuff with the metal and the fiber.

Assessment of water-fastness was done by standard methods: the conditions of washing liquors vary from one representing mild hand washing (ISO 1) to one intended as an extremely severe hot alkaline washing test for cellulosic fibers (ISO 5). The tests most commonly applied to wool textiles are the intermediate ones, ISO 2 and ISO 3, the former involving a treatment of the dyed textile in a solution of 5 g/litre soap solution at 50^0 +/- 2^0C for 45 minutes, while the more severe ISO 3 test consists of a treatment in a solution containing 5 g/litre soap and 3 g/litre sodium carbonate at 60^0 C for 30 minutes. ISO 2 has been used as the standard test in the present work. The dyed wool pattern for testing (10 x 4 cm) forms the centre of the sandwich formed by stitching it between an undyed piece of cotton and an undyed piece of wool (both 5 x 4 cm), leaving a portion (5 x 4 cm) of the pattern uncovered. After the washing test, the fastness is assessed using the geometric grey scales for:

(i) the effect on the pattern, i.e. loss or change of colour; and

(ii) the staining of adjacent white material-cotton and wool.

The response of some natural dyestuffs on wool indicates that out of all these dyes, the vat dye indigo shows the best all-around fastness. This is because vat dyestuffs possibly have the highest all-around fastness of any class, though almost exclusively used on cellulosic fibers. Logwood is also good though giving rise to some staining, but of the others, only fustic and alizarin on an aluminium mordant show up reasonably well. Persian berries, cochineal, lac, alizarin (tin mordant), and quercitron have poor fastness, particularly with respect to the effect on the pattern. Normally this figure represents an one-tone reduction in colour which is a function of the intrinsic affinity of the dye for the fiber, but this is the case only with sulphonated indigo of the dyestuffs tested.

Manek (2012) did the documentation of rare textile artefacts with focus on preservation and conservation wherein the investigator documented, digitized and analysed the rich textile artefacts of selected individuals from Gujarat. The intensive efforts were made to develop the digital database for the greater access to these rare artefacts. Workshops were also organized at the house hold level to raise awareness about the preventive conservation amongst the possessors of these artefacts. Total 95 rare textiles were documented out of which 47 were woven silk textiles from the states of Gujarat and Uttar Pradesh and 40 embroidered artefacts. The documented artefacts also included five resist dyed and three printed artefacts. The data was analysed on the basis of the category and types of damages the textiles had. It was found that 68 artefacts were damaged out of the total 95 rare textile artefacts. Physical damages such as cuts, creases, tears, folds, breakage of yarns, etc. were noticed in 37 artefacts whereas chemical damages and biological damages such as holes, brown spots were noticed in seven artifacts. The artefacts were further classified on the basis of the severity of the condition and it was found that 32 artefacts were in good condition, 27 in excellent, 25 in fair and 11 in poor condition. An experimentation was done on traditional silk saree in order the find out the best possible treatment for securing the torn area by using nylon net as the support fabric. The treatment was carried out by using 5% and 10% concentration of poly vinyl acetate (PVA) and poly methyl methacrylate (PMMA) by cold and hot method. The adhesive prepared in the required concentration was applied over the nylon net of the required size. The consolidated samples were prepared and tested for tensile strength, stiffness test and transparency properties.

10% PVA by cold method was found out to be the best method for the conservation of the aged-silk textiles. The data pertaining to the overall study revealed that preventive conservation should be emphasized as it can be practiced with the least available resources.

Ford (1992) quantitatively monitored the extent of colour change associated with the display, under museum conditions, of Asian textiles over a three-month period by using a portable tristimulus colour analyzer. Four ISO blue wool fading standards (ISO R105, standards 1-4) were concurrently exposed in order to provide a comparative fading rate scale [12-15].

For the experimental procedures, British Standards Institute blue wool fading standards (also ISO R105) 1-4 were mounted on the wall in a typically lit area of the exhibition (95 lux). The total exposure time was 945 hours resulting in a cumulative exposure of 89-77 x 103 lux hours. The chemical name of natural dyes in this study which are commonly used in Southeast Asia is indigo tin, lacceroic acid, morin done tannin, curcumin, brasilein, alizarin, and Fe tannin.

Figure 2.10: The usage of Minolta Chroma-Meter

The use of the Minolta Chroma-Meter for the measurement of the colour co-ordinates of dyed textiles on display. The colour head is accurately positioned by relating marks on the circular Perspex template to designs on the textile.

Source: http://www.jstor.org

For the results, the colour coordinates of a piece of blue wool fading standard were measured five times over 15 minutes (three minutes between readings). This was repeated at intervals of one week for four weeks in order to measure long-term reproducibility.

It was found that out of the 52 dyed areas tested, 39 were judged either to have faded significantly or to have faded very little; for the remaining 13, the errors involved in replication were so large as to render them non- significant according to the criteria adopted.

Brimblecombe *et. al.* (1992) studied wool and reduced sulfur gases in museum air. Wool releases plenty of degraded sulfur fumes while storing. This release is enhanced under UV and even sunlight irradiation or when hot (50^oC). Carbonyl sulfide is the principal sulfur gas found, along with traces of carbon disulfide and, in the case of short wavelength irradiations (to 254nm), hydrogen sulfide. The presence of significant amounts of water (20-80% wool weight) markedly increases the release of COS and CS_2.

The method was adopted wherein the small quantities of fiber (1-5g) or occasionally pure chemical reagents were held in Pyrex or quartz tubes ($120cm^3$). The tubes were sealed with adapters that held 1 I mm septa to allow gas to be removed from the headspace with a syringe. A Camag type 27,000 source at about 5cm using either the 254nm or 365nm settings was employed to irradiate samples with a mild intensity UV light. On other occasions, samples were exposed to October-November sunlight (Austral spring) at 400 south latitude. The gas above the wool was analyzed using a Perkin Elmer 8500 Gas

Chromatograph with a 1-8m Teflon column (o.d. 3mm) packed with Carbopac B/1.5% XE60/1% H_3PO_4 and nitrogen as the carrier gas. It was temperature programmed to allow reasonable separation of the principal gases of interest (hydrogen sulfide, carbonyl sulfide, methanethiol, dimethyl- sulfide, carbon disulfide) within 10 minutes. The sulfur compounds were detected by flame photometry.

The observations made in the experiments on the release of sulfur gases from wool were reasonably consistent with work done in the past. The release of H_2S from wool under powerful UV irradiation was observed. More recently, there has been the use of mass spectroscopy to identify the release of CO_2, CO, H_2, COS, H_2S and CS_2 (in order of amounts) from wool irradiated at 254nm, CO_2 and CO from irradiations at 436nm. Although much work has been done on the photochemistry of wool the exact mechanism for its photodegradation remains unclear. One of the most important results of these experiments is the qualitative observation that it is COS rather than H_2S that is released from wool. It is only recently that COS has been regarded as a tarnishing agent for metals such as copper and silver.

The results of work agree well with general observations that suggest wool degrades through thermal or photochemical degradation of the cysteine-containing protein. Although wool releases carbonyl sulfide COS over time it also slowly absorbs COS from the air. The release of sulfur fumes from textiles into indoor gallery air is seemingly not a critical issue regarding the potential importance of other sources such as individual bioeffluents. However, within display cases, problems are likely where wool, feathers or similar materials are displayed with metals.

Reagan (1982) studied the various methods available for insect control on wool textiles.

The study presented an overview of chemical and non-chemical methods of pest control applicable to the museum and home use. In addition to common methods of controlling insect growth on wool textiles, several unusual and alternative chemical, biological, and nonchemical methods of pest control were researched. This research also concentrates on eliminating the methods for restraining fabric pests, precautionary measures (i.e., good housekeeping practices and periodic inspection of wool, feathers, furs, etc.) can reduce the risk from insect groups into houses and storehouses or implementing conditions that favor insect evolution.

The bulk of insect damage to wool is assigned to the common or webbing clothes moth and the black carpet beetle; other insects and species of clothes insects and carpet bugs, however, also may cause significant harm.

Some of the common forms of available insecticides for controlling fabric pests include fumigants, repellents, sprays, specks of dust, aerosols, fogging concentrates, impregnates (mothproofing agents), and attractants. These terms often reflect the mechanism by which the insect is controlled.

A recent research on pest control practices in museums stated that additional research is needed to develop safe and effective nonchemical methods of controlling insect growth. Extreme fluctuations in warmth have been used to a confined space to disinfest textiles. For example, controlling textiles to temperatures below freezing (i.e., -18^{o}C for 4 hours or 0^{o}C for several days) can be effective in destroying fabric pests. An optional, non-chemical technique of disinfesting textiles is microwave radiance. In assessing the potential of using microwave radiation for disinfesting wool textiles, the effects of microwave radiation on selected physical and chemical properties of new and old wool fabrics were evaluated. Specific tests performed on the new wool included breaking strength, elongation, shrinkage, moisture regains, colour change (yellowing), and alkali solubility. Scanning electron micrographs were obtained of fiber parts from both new and old wool specimens before and after they were illuminated with microwaves to ascertain if any exterior changes might have happened in the fibers after the operation. The experimental method was conducted where the egg, larval, and adult stages of the webbing clothes moth were exposed within a 2.2 m sample of wool gabardine that weighed 832.4 g to determine the time required to disinfect the amount of cloth used in an "average" wool garment. The wool gabardine samples were conditioned for 24 hours and then folded so that the final dimensions of each were 22.5 X 30.0 cm.

Figure 2.11: Fabric/film bag containing 10 insects is placed inside 2.2 m of wool gabardine.
Source: cool.conservation-us.org

The conclusions of a study on the probability of using microwaves as nonchemical methods for insect restriction:

The results showed the times required to obtain 100% mortality in the egg, larva, and adult clothes moth were 3.0, 2.0, and 2.0 minutes, respectively. Hence, 3.0 minutes of microwave exposure was sufficient to kill all three stages of the insect in a 2.2 m sample of wool gabardine.

Hence, the researcher concluded that in this study, 3 minutes of microwave exposure was sufficient to obtain a 100% mortality in the egg, larval, and adult stages of the webbing clothes moth in a 2.2 m sample of wool gabardine with minimal effects on the chemical and physical properties of wool. Prolonged periods of microwave heating should be avoided, however, as wool may suffer degradation at temperatures above 100^{o}C. Ten minutes of microwave irradiation, which represented prolonged heating in this study, produced internal fabric temperatures of 149^{o}C and caused an increase in alkali solubility, shrinkage and colour difference when confronted with the unexposed specimens or those illuminated for 3 minutes.

Bresee (1986) examined the effects of five types of ageing on textiles. The types of ageing are physical, photochemical, thermal, chemical and mechanical which resulted in changes in the original structure and material properties of textiles.

In physical ageing, strictly mechanical anatomical changes occur over the period, and no extra energy needs to be provided for physical ageing to happen. A fiber that has physically aged can be expected to be harder, more dense, stiffer and it exhibits increasing viscoelastic relaxation times as compared to the same fiber that has not been aged physically.

Photochemical degradation results from chemical changes when additional energy is supplied to materials through the absorption of electromagnetic radiation (photons), such as visible or ultraviolet light. The fundamental source of deterioration of chemical or physical properties is chemical changes in the polymer composition. In simple terms, chemical changes are those involving destruction and formation of covalent bonds. Unlike physical ageing, which happens only in non-crystalline regions of polymer substances, photochemical degeneration proceeds in both crystalline and noncrystalline regions as electromagnetic radiation can enter both areas.

Thermal degradation occurs when structural changes result from the absorption of thermal energy (heat). Chemical attack may result in ageing when energy is supplied to materials through the attack by external chemical species, such as when oxidation occurs from peroxide bleach. Certainly, ageing may happen through mechanical tension, such as when the gross shape of textiles changes as a result of sagging during display or storage.

Five types of ageing were classified, and the general influences of each of them on textile fabrications and characteristics were discussed. The structure and properties of historic textiles were assumed to vary considerably since vulnerability to each type of ageing would be expected to vary considerably among the group of naturally aged textiles. Conservators should follow these considerations and vary methods considerably for different textiles. Many trade-offs are confronted with conservation operations. For example, wet cleaning obliterates physical ageing and eliminates dirt from fibers.

This would result in the decrease in stiffness, hardness and viscoelastic relaxation times as well as less polymer chain scission, fiber deformation and fracture during handling. However, a potential for loss of dye or finish from fibers, crystallization, and diffusion into fibers of surfactants or soil removed from the textile increases. By being conscious of the general effects of ageing on textiles, one is more able to become aware of the general chemical and physical nature of the object being dealt with. In addition, one is alerted to the potential benefits and dangers that accompany various conservation treatments.

Long *et. al.* (2004) studied the mechanism of pilling and tested the pilling of a series of worsted fabrics made from wool/ polyester fibers using a circular locus pill tester. The process and mechanism of pilling were studied through the observation of fiber morphology on the fabric surface by using a scanning electron microscope. It was observed that the condition of a test, structure of yarn, wool content and property of polyester fibers affect the pilling of worsted fabrics.

The present work was aimed at studying the pilling performance of wool/polyester worsted fabrics. The polyester fibers were replaced by modified polyester fibers. The strength and modulus of modified polyester fibers were 2.5 cN/dtex and 26N cN/dtex. respectively. The strength and modulus of normal polyester fibers were 3.8 cN/dtex and 50 cN/dtex respectively.

The samples were brushed using a nylon brush and then abraded using the same fabric. The pilling performance of fabrics was evaluated according to pill numbers on the fabrics.

Under the conditions of 0.5 min brush time and 0.9 min abrading time, the fabrics 1 and 3 (made of wool/polyester fibers) show few pills, whereas fabrics 2 and 4 (made of wool/ modified polyester fibers) show no pills at all. Thus, the brushing and abrading at a short time have little influence on the pilling of the sample.

Therefore, it was observed that the pill numbers of all the samples increase with the increase in brush time. The pill numbers of wool/modified poly fibers are fewer than that of wool/polyester under the same fabric's specification. It was also observed that the fibers on yarn surface are pulled out or broken with the increase in brush time.

The results during testing showed that the pills made of wool were removed easily due to the low strength of wool. Therefore, the structure of yarn of wool/polyester is related to pill on the fabric. The fabric of wool/modified polyester fiber has a high pill resistance because of the low strength and modulus of modified polyester fibers which led the pill to worn-off easily.

Conclusion

The review of literature was carried out to acquaint with the existing body of knowledge in the area of shawls' conservation in India through its historical background from four different states in particular. It not only gave a theoretical background for the study but also proved helpful in setting up the guidelines for the preservation and conservation of shawls. The investigator reviewed, various studies of international as well as national level to carry out the research. It got cleared from the literature survey that there were more number of experimental researches happened in abroad as compared to India.

These studies served to gain fundamental information of fibres, its identification, structures and dyeing techniques. The agents responsible for shawls' deterioration and its preventive conservation techniques further enhancing the skills needed by any conservation scientist were also discussed. This suggested the possibilities of taking the correct measures for shawls' conservation through a holistic approach.