Progress Report

BIS Sponcered Project

On

A comprehensive study of the constructional and performance requirements of scaffolding nets used in construction activities for high-rise buildings/structures

by

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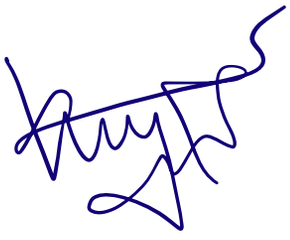
Jalandhar

Contents



1. Introduction

Infrastructure development is significant for the growth of a country, and the construction industry plays a very important role in it. The construction industry in India provides the maximum number of employment opportunities after agriculture and is considered one of the most hazardous. Indian construction workers make up approximately 7.5% of the global labour force and account for 16.4% of fatal occupational accidents worldwide. According to recent International Labor Organization (ILO) research, India has the highest accident incidence among construction workers worldwide. A survey conducted by a local charity agency found that 165 out of every 1,000 workers are injured at building sites[1], [2], [3]. The data represented above is alarming, and effective utilisation of personal protection equipment at construction sites needs to be promoted at the mass level. Fall from height and injury caused by falling objects like debris, etc., are the two major causes of accidents on construction sites, and the second one is considered in this research proposal.

Scaffolding nets, also called debris nets or safety nets, are lifesaving equipment used in high-rise building construction. It is a protective barrier around the site that prevents objects from spreading and protects the workers and people near the construction site from falling over hand tools, bricks, debris, and other building materials. These are raschel knitted high-density polyethylene (HDPE) nets having small mesh opening, which traps falling objects and allow air to cross through them. According to OSHA standard of safety nets 1926.105 (d), the mesh size of the nets shall not exceed 6 inches by 6 inches, and all new nets should have a minimum 17,500-foot-pound impact resistance. Edge ropes shall provide a minimum breaking strength of 5000-pound force. Important parameters deciding the performance of debris nets are filament material properties, the structure of the net (raschel knitted, twisted, knotless, braided), the mesh size, and the GSM of the net. The performance of nets can be evaluated in terms of breaking strength and elongation, impact resistance, bursting strength, tearing and abrasion resistance, air permeability (wind loads), weathering resistance (UV, Temperature, and Relative Humidity), flame retardancy, snd soil & oil resistance [4], [5], [6]. It is observed that safety nets are very rarely used on construction sites in India. Even though the nets are used in a few construction sites, the agriculture shade nets are mostly used. These agriculture nets do not provide the required protection. Along with personal protection, these nets are also recommended for the

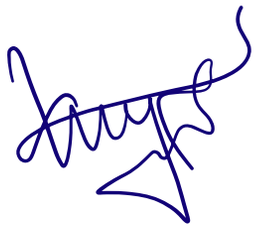
prevention of air pollution in the guidelines issued by various agencies, such as the Environmental Impact Assessment guidance manual for construction projects (by the Ministry of Environment and Forest), Brihan Mumbai Municipal Corporation, etc. There are a few manufacturers and traders, such as GreenPro and Kwality Nets Mfg. Co., Fortune Agronet in India, who produce/supply scaffolding nets but the construction details and properties of the net are not disclosed in available literature. Moreover, no legal requirements or standards on scaffolding nets are enforced at construction sites in India. In developed countries such as the USA, UK, and Europe, strong safety policies and strict law compliance enforce the use of standard safety nets at construction sites. There are guidelines for establishing scaffolds on construction sites, but no detailed contents related to scaffold nets. The American Standard, ANSI/ASSP A10.11-2010 (R2016), and European standard BS EN 1263-1:2002 specify the requirements for the selection, installation, testing, and usage of personnel safety nets in the construction sector, as well as repair and demolition activities. The ANSI/ASSP A10.37-2016 covers the debris nets, including minimal standards of netting system design, selection, installation, testing, and usage.

1.1 Objectives

Considering the importance of scaffolding nets in the construction industry, the objectives of this research proposal are as follows.

- To study the effect of filament material, mesh size, and net structure on material behaviour during tensile, tearing, bursting, and tensile impact testing.
- To study the change in material properties during and after tensile, tearing, bursting, and tensile impact testing.
- To study the effect of exposure to various degrading factors such as abrasion with sharp edges, sunlight (UV), temperature, dust particles, and moisture on the performance of nets.
- Optimization of material type, mesh size, and net structure based on testing results for designing and standardizing the scaffolding nets.

1.2 Scope



The proposed research project would provide technical information on the effect of various process parameters on the performance of the scaffolding nets, which will help in the standardization and design of advanced nets.

2. Literature Review

2.1 Scaffolding nets

These are high-performance textile material nets used to cover the scaffolds vertically at construction sites. The major functions of scaffolding nets are the safe containment of debris and ensuring the safety of the working staff, people and traffic near the construction site. These nets act as windbreakers, allowing required airflow, controlling dust and providing a sun shading effect. As an enclosed system, it is simple and affordable to handle, and it can hang vertically to obtain optimum coverage. The edges are strengthened with eyelets for fast and simple mounting to a scaffold using wire or plastic ties [7].

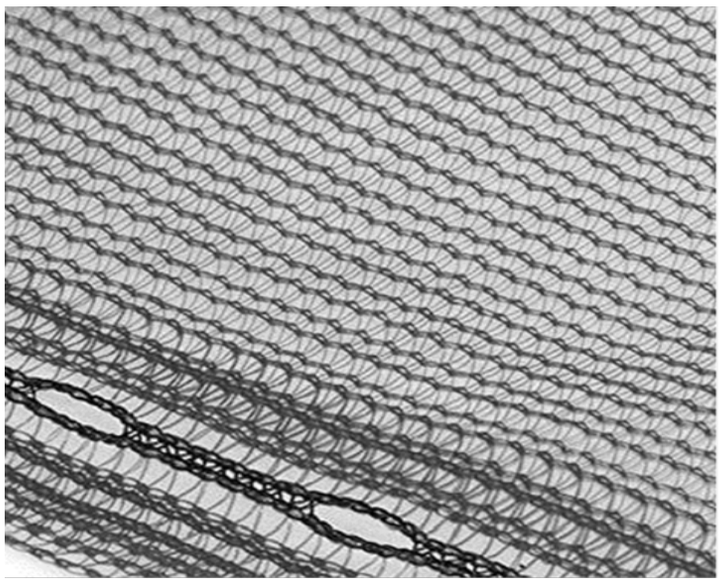


Fig 2.1 Scaffolding net used at construction sites [7]

2.1.1 Classification of Scaffolding nets

Scaffolding nets can be classified based on many factors, such as type of application, manufacturing technology, structure and material used. Classification based on many factors is shown below in Table 2.1.

Table 2.1 Classification of scaffolding nets

Classification criteria	Types
Raw material	HDPE, PE, PET, PP, HDPE and Nylon nets
Mesh Size	Small, medium and coarse mesh size
Manufacturing technology	Knitted, woven, knotted, braided
Special features	Flame retardant, UV resistant, weather resistant

2.1.2 Raw materials

HDPE (High-density polyethylene) is the most preferred material used in scaffolding nets due to its high strength, durability and resistance to chemicals, UV radiations, moisture and weathering. UV absorbent materials are added while manufacturing the HDPE filaments to increase their resistance to UV radiation. Some other materials, such as Polyethylene, Polypropylene (PP), Polyester (PET) and Nylon, are also used in scaffolding nets according to the specific requirements. Polypropylene has high strength, lightweight and moisture resistance. Polyester is well known for its tensile strength, low stretch, stiffness, durability and weathering resistance. Nylon has exceptional elastic recovery, which makes it suitable for energy absorption. Surface modification is done for nylon to increase its weathering resistance. These materials are sometimes combined with HDPE to fulfil specific requirements [8], [9], [10].

2.1.3 Manufacturing techniques

Scaffolding nets can be manufactured using warp knitting, weaving, knotting and braiding. In warp knitting, Rachel knitting technology is generally preferred as it provides flexibility in designing fabric structures according to requirements. It provides the choice of manufacturing

dimensionally stable or elastic fabric, open or dense construction, etc.

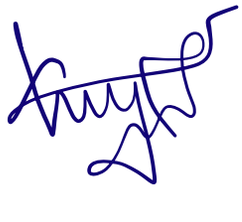
Nets produced on warp knitting machines are ‘knotless’ constructions. The single or double -bar raschel machines are used to produce these nets. The yarns from warp beams are fed to the warp knitting machine to produce the net fabrics. In this case, all the yarns are processed vertically into the connecting sections. The guide bars are moved to the adjacent connecting section at specific intervals, which produces the joint or so-called ‘knot’. These joints don’t have bumps, so they are called knotless nets. On the other hand, knotted nets are produced by knotting yarns that have already been twisted together in a specific cycle to form a net. The connecting sections and joining points (knots) can vary depending on the mesh size required, and adjustments are made via the lapping. The knitting technology allows the knitting operative to easily lengthen or shorten the knots and the connecting sections for the same yarn use. The weight changes slightly when the mesh size is changed. The width of warp-knitted nets is always specified along with the number of mesh openings in the net since the maximum span width of the nets will vary according to the mesh size and the relationship between the knot length and the length of the connecting sections [8].

Weaving, braiding and knotting are the other methods used for net production. Weaving is generally used to produce nets with a very small mesh size. Changes in the mesh size are done by adjusting the spacing between the warp and the weft. Knotting is a traditional method of net manufacturing in which the desired mesh size is achieved by tying the yarns at specific intervals. Nets manufactured by knotting have higher load-bearing capacity. The knotting method can be manual, semi-automatic, or fully automatic, depending on the production volume and required net size and strength.

Braiding is another method of net production known for providing flexibility, strength and consistency to the nets. Braided nets are ideal for applications that demand strength, abrasion resistance, and load-bearing capability. Unlike weaving and knotting, which interlace threads at intersections, braiding involves interweaving several yarns or fibres in a continuous diagonal pattern. This method produces a more compact and resilient network structure.

2.1.4 Construction particulars

Structure (knotted or knotless), mesh size, and GSM are important construction characteristics of scaffolding nets. These construction particulars will depend on several interdependent factors such as the lapping, number of guide bars used, machine gauge, yarn threading arrangement, stitch density and type of yarn. Most nets on single-bar raschel machines are



produced by a pillar stitch-inlay lapping or other simple basic constructions. The loops in the various lappings can be processed to open or closed. The most frequently used basic lappings are pillar stitch, Inlay (weft), Tricot and 2 x 1 lapping.

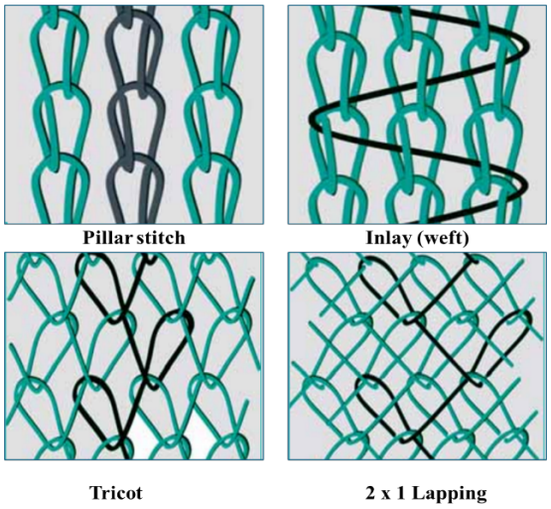


Fig 2.2 Frequently used basic lappings on Raschel machines [8].

Net openings of various sizes and shapes can be produced in several different ways, in which case, the choice of gauge, construction and stitch density are decisive factors in determining the shape and size of the openings. Another factor is the yarn threading arrangement into the guide bars. This does not necessarily have to be identical to the machine gauge. Because of the many possible end-uses, threading arrangements of 1 in, 1 out, 1 in, 2 out, etc., are often used for these products. The advantage for the manufacturer is that a wide range of products can be produced on one machine without having to carry out any time-consuming changeover procedures [8].

2.1.5 Performance testing

Performance testing is done using drop test method. According to standard EN 1263-1:1997, the safety nets should be able to absorb 7 kJ kinetic energy, which corresponds to the potential of a mass of approximately 100 Kg falling from a height of approximately 7 metres (2 floors of approx. 3 metres plus 1 metre to the centre of gravity). According to OSHA guidelines debris net should withstand a minimum of 17,500 pounds of impact resistance.

According to drop test method given in American standard ANSI/ASSP A10.11-2010, debris net having size 5.2×7.3 m is placed in a frame and a 350 lb sandbag having diameter 24 inch and height 36 inches is dropped from 50-foot height on the net at three points after

intervals of five minute. The dropped sandbag should be arrested by the net without any damage to the net for passing the test.

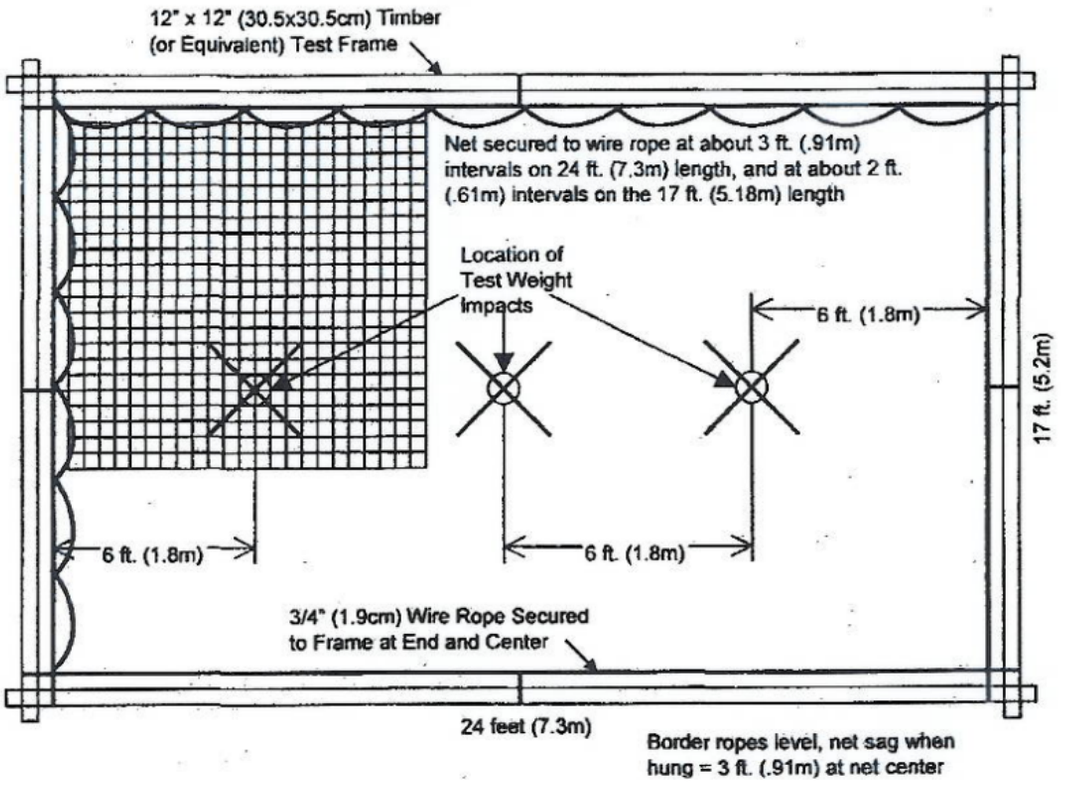


Fig 2.3 Net testing frame plan as per standard ANSI/ASSP A10.11-2010

Following tests should be performed for performance testing

- Drop test (dynamic loading)
- Tensile testing (quasistatic loading)
- Tearing testing
- Abrasion testing
- Bursting strength
- UV resistance
- Air permeability
- Flame retardancy
- Soil resistance
- Oil resistance

2.1.6 Factors Deciding Performance

Material strength and load bearing capacity, net structure, mesh size, GSM and resistance to weathering are the major factors determining the performance of scaffolding nets.

2.1.7 Advancements in raw materials and manufacturing technology

Use of lightweight materials improves portability and ease of installation. Intelligent monitoring systems having sensors detect damage and alerts workers. Automatic installation using robotics streamlines setup process.

3. Questionnaire

1. Manufacturer details

Name of company	
Type of company	(Small/Medium/Large)
Certifications	

2. Data on the requirements of raw material (Filament Yarn)

Material	HDPE	PP	PET	Nylon
Mono/Multi Filament				
No of Filaments				
Denier				
TPI				
Strength (gpd)				
Elongation (%)				
Modulus (MPa)				

Details of testing of raw material, including test methods and instruments used

Parameter	Testing Equipment	Testing standard
Denier		
TPI		
Strength (gpd)		
Elongation (%)		
Modulus MPa		

UV resistance		
Abrasion resistance		
Weathering resistance		

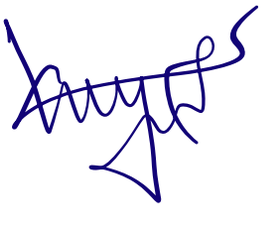
3. Scaffolding net construction details

Structure (Woven/Warp or Weft knitted/ other)				
Lapping				
No. of guide bars				
Thread density (EPI& PPI or courses & Wales per inch)				
GSM				
Mesh size				

4. Performance evaluation

Drop test (dynamic loading)				
Tensile strength				
Elongation at break				
Tearing testing				
Abrasion testing				
Bursting strength				
UV resistance				
GSM				
Air permeability				
Flame retardancy				
Soil resistance				
Oil resistance				

5. Manufacturing process
   - Method used for manufacturing
   - Process flow chart with names of machines



- Range of process parameters used at various machines
- Details of ambient conditions
- Details of manpower utilized section-wise
- Details of commonly running products along with structure and construction parameters

6. In-process controls being exercised during manufacturing
   - Details of methods and technology used for process control
   - Details of QA practices used section-wise
   - List of dos and don’ts section-wise

7. Testing method being used.
   - Testing methods and standards followed for testing of in-process material and final product
   - Details of third-party testing, if any

8. Testing infrastructure available.
   - Details of testing infrastructure at the company campus
   - Details of labs used for third-party testing, if any

9. Post-manufacturing quality/in-house data for all the varieties being manufactured.
   - Details of technical specifications of all products
   - Testing results of final products (Strength, elongation, bursting strength, UV resistance, wind flow rate, service life)

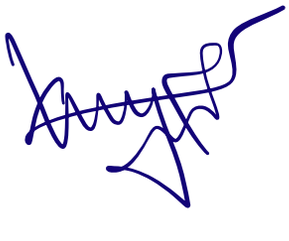
10. Sampling plan being followed.
    - Details of technology, including machine details used for manufacturing samples
    - Sampling size

11. Marking and labelling of the product.

12. Packaging requirements and storage conditions

13. Sustainability practices [sustainable raw material, energy-efficient processes and methodologies, renewable energy sources, 3Rs (Reduce, Reuse and Recycle), waste management and disposal mechanisms]

14. Focused group discussions with teams involved in production, testing, and R&D to address quality issues, discuss challenges faced and gather suggestions for improvement.



4 Manufacturer details

Industry Name	Location	State	Type	Products	Raw Materials	Mesh Size	GSM
Garware Technical Fibers	Wai	Maharashtra	large	Triple-Layered Safety Nets, Safety net with containment nets	PPMF/Nylon/HDPE Twine	60, 100 mm	NA
Rishi Techtex ltd	Silvassa	Daman and Diu	Medium	Scaffolding nets	NA	NA	115
RAD Global Private limited	Jaipur	Rajasthan	Small	Scaffolding nets	NA	NA	120
Fortune Agro Nets	Vapi	Gujarat	Small	Scaffolding nets	HDPE	NA	NA
GreenPro Ventures Pvt Ltd (Rishi FIBC)	Chamrajanagar	Karnataka	large	Scaffolding nets	HDPE	NA	32-220
Jeetmull Jaichandlall Madras private limited	Chennai	Tamil Nadu	Small	Scaffolding nets	NA	NA	NA
Ozone Agro Industries	Morbi	Gujarat	Small	Scaffolding nets	Plastic	NA	80-150
S S International (SS ROPES)	Delhi	Delhi	Small	Scaffolding nets	NA	NA	NA
Satva Agrishade Net	Ahmedabad	Gujarat	Small	Scaffolding nets	HDPE	NA	80
Sri Vallabh Enterprices	Mumbai	Maharashtra	Medium	Scaffolding nets	NA	NA	NA
Kwality Nets MFG. Co	Mumbai	Maharashtra	Small	Scaffolding nets	HDPE	NA	NA

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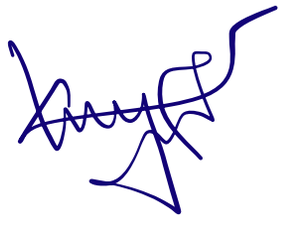

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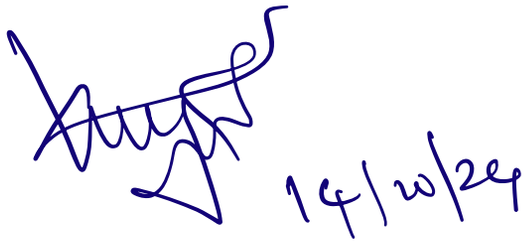

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Reference: NITJ/DRC/
Date:

File number and Date : **SCMD/R&D Projects/TXD 0031 & 15.07.2024**
Project Title : **A comprehensive study of the constructional and performance requirements of scaffolding nets used in construction activities for high-rise buildings/structures**
PI Name : **Dr. Palaniswamy N K**
Institute Name : Dr. B. R. Ambedkar National Institute of Technology, Jalandhar
Project start date : 22.07.2024
Duration : 4 Months
Total budget (Revised): 7,50,000 INR
Status : Ongoing

Statement of Expenditure (From 22.07.2024 to 21.10.2024)

S. No.	Budget Head	Sanctioned Budget (INR)	Budget Released as 1st Installment on 22.07.2024	Expenditure incurred from 22/07/2024 to 14/10/2024
	Non-Recurring/Capital Cost			
1.	Equipment Cost	0	0	0
	Recurring /General Cost			
1.	Manpower Cost	0	0	0
2.	Contingency	0	0	0
3.	Consumable	5,00,000	1,35,000	10,932
4.	Travel	1,50,000	40,500	0
5.	Miscellaneous	0	0	0
6.	Overheads	1,00,000	27,000	0
7.	Interest accrued (if any)	0	0	0
Total		7,50,000	2,02,500	**10,932**

21/10/24
Signature of PI:

Signature
Name:
(Head of the Institute)

Assistant Registrar
Audit & Accounts
Dr. B.R. Ambedkar
National Institute of Technology
Jalandhar-144011 (Punjab)

Chief Finance Officer

22/10/24

24/10/24
Signature
Name:
Organisation

Registrar
Dr. B.R. Ambedkar
National Institute of Technology
Jalandhar-144011 (Punjab)

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY, JALANDHAR
GT road, Amritsar Bypass, Jalandhar, Punjab 144008, Email id registrar@nitj.ac.in

Ref.No:

Date: 21 October, 2024

GFR 12 – A [(See Rule 238 (1)]

FORM OF UTILIZATION CERTIFICATE FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE
of recurring
GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the grant Receiving Organization : Dr B R Ambedkar National Institute of Technology, Jalandhar-144008
Name of Principal Investigator(PI) : **DR PALANISWAMY N K**
Sanction order no. & date : **SCMD/R&D Projects/TXD 0031 & 15.07.2024**
Name of the Project: **A comprehensive study of the constructional and performance requirements of scaffolding nets used in construction activities for high-rise buildings/structures**
Name of the Scheme: R&D
2. Whether recurring or non-recurring grant: **Recurring and nonrecurring**
3. Grants position at the beginning of the Financial year : 2024-25
(i) Cash in Hand/Bank : 2,02,500 INR
(ii) Unadjusted advances : **NIL**
(iii) Total : 2,02,500 INR
4. Details of grants received, expenditure incurred and closing balances: (Actuals):

Unspent Balances of Grants received years [figure as at Sl. No. 3 (iii)]	Interest Earned thereon	Interest deposited back to the Government	Grant received during the year			Total Available funds (1+2-3+4)	Expenditure incurred	Closing Balances (5-6)
1	2	3	4			5	6	7
0	**0**	**0**	Sanction No (I) SCMD/R&D Projects/TXD 0031	Date (II) 15/07/2024	Amount (III) 2,02,500	2,02,500	**10,932**	**1,91,568**

Component wise utilization of grants:

Grant-in-aid–General	Grant-in-aid–creation of capital assets	Total
1. Consumable: **10,932**	**0**	**10,932**

Details of grants position at the end of the year:21.10.2024
(i) Cash in Hand/Bank: **1,91,568** (Balance amount laps on 21.10.2024)
(ii) Unadjusted advances: **NIL**
(iii) Total : **1,91,568**

21/10/24
Signature of PI:

22/10/24
Assistant Registrar
Audit & Accounts
Dr. B.R. Ambedkar
National Institute of Technology
Jalandhar-144011 (Punjab)
Signature
Name
Chief Finance Officer
(Head of the Finance)
22/10/24

24/10/24
Registrar
Dr. B.R. Ambedkar
National Institute of Technology
Jalandhar-144011 (Punjab)
Signature
Name
Head of the Organisation

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY, JALANDHAR
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Ref. No:-

Date:21-October-2024

Principal Investigator(PI) : **DR PALANISWAMY N K**
Duration: **01-04-2024 to 21-10-2024**
Name of the Project: **A comprehensive study of the constructional and performance requirements of scaffolding nets used in construction activities for high-rise buildings/structures**

Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

(i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

(ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

(iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.

(iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.

(v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

(vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

(vii) It has been ensured that the physical and financial performance under **BIS R&D Project** (name of the scheme has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given at Annexure – I duly enclosed.

(viii) The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.)

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Date: 21.10.2024
Place: Jalandhar

24/10/24
Signature of PI

22/10/24
Assistant Registrar
Audit & Accounts
Dr. B.R. Ambedkar
National Institute of Technology
Jalandhar-144011 (Punjab)
Signature
Name
Chief Finance Officer
(Head of the Finance)

24/10/24
Registrar
Dr. B.R. Ambedkar
National Institute of Technology
Jalandhar-144011 (Punjab)
Signature
Name
Head of the Organisation

(Strike out inapplicable terms)\

ANNEX E

OPERATION OF FUNDS AND PROGRESS REPORT

1. Title of the Project: A comprehensive study of the constructional and performance requirements of scaffolding nets used in construction activities for high-rise buildings/structures.	Project number: TXD0031
2. Name & Address of Project leader: **Dr Palaniswamy N K** Department of Textile Technology, Dr B R Ambedkar National Institute of Technology Jalandhar	Date of Commencement: 22/07/2024

3. Details of Equipment Purchased (if any):

Name of equipment	Cost	Supplier	Date of purchase/ placing order for each item of equipment
NA	**NA**	**NA**	**NA**
NOTE - The equipment fund once fixed cannot be enhanced. Project leaders are advised to give authenticated estimates of the cost of equipment. Equipment should invariably be purchased within 1 month from the date of receipt of the fund and/or sanction letter.			

4. Fund received **2,02,500** INR
5. Expenditure made in Rupees: (Please provide the details)

Expenditure	Amount	Taxes (as applicable)	Total
Manpower cost	0	0	0
Consumable	10,932	0	10,932
Equipment	0	0	0
Travel	0	0	0
Others	0	0	0
Grand Total	10,932	0	10,932

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Remark: -

- Approval for industrial visit and sampling is under progress, and visits are planned for 18th-19th October.
- Proposed travel expenses would be around 1,00,000 INR
- Proposed amount for the purchase of samples would be around 1,00,000 INR

6. Amount saved (if any) from the last instalment: **Rs 1,91,568 INR.**

7. Date on which scheme will complete its normal tenure of months: **21/11/2024**

8. Whether extension beyond normal tenure has been requested: **No**

If yes, justification for extension and programme of work to be completed. Also mention as to why the work could not be completed as per the original plan.

{Extension beyond normal tenure should be requested at the Project Monitoring Session before end of tenure (as given in ToR)}.

9. Constraints (if any) faced in the progress of work and suggestions to overcome them…
   - **No reply from industries on the questionnaire shared.**
   - **Facing difficulties in getting permission from industries for visits and sample collection.**
   - **Need of budget for the manpower (it was not proposed in the original/sanctioned project. However, manpower is very much required for the execution of the project. Hence a request for a grant for manpower and redistribution of budget has been submitted for approval.**
   - **In the first instalment, the budget for travel is not sufficient to visit various industries across the country.**

10. Any deviation from original plan with its nature and cause: **Nil**

11. List of publication giving full bibliographic details accrued from this project (copies of the paper (s) should be enclosed): **Nil**

12. Summary of work done (200 words).

    - The literature review report was submitted to the BIS. An online survey of the industries involved in the manufacturing of scaffolding nets was done, and the questionnaire was shared via email. The telephonic conversation was made with industries to get permission for a visit to Maharashtra, Tamil Nadu and Karnataka, and the tentative dates for the visit are 18-19 October 2024.

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13. Proposed programme of work for the next month (1000 words).

- Industrial visit and sample collection
- Testing of samples
- Analysis and documentation of results.

14. Detailed Progress Report enlisting the objectives in beginning briefly (up to five pages maximum).

(Attached)

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Signature of Project leader

Date: 14.10.2024